Volume 2

Water Resources

ILLINOIS RIVER BLUFFS AREA ASSESSMENT

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

ILLINOIS RIVER BLUFFS
AREA ASSESSMENT.

DATE	ISSUED TO
~~8/23/01~~	~~[illegible]~~

IDNR
CTAP
AA
IRB
v.2
99062906

ILLINOIS RIVER BLUFFS
AREA ASSESSMENT.

Illinois River Bluffs Area Assessment

Volume 2: Water Resources

Illinois Department of Natural Resources
Office of Scientific Research and Analysis
Illinois State Water Survey
2204 Griffith Drive
Champaign, Illinois 61820
(217) 244-5459

1998

Jim Edgar, Governor
State of Illinois

Brent Manning, Director
Illinois Department of Natural Resources
524 South Second
Springfield, Illinois 62701

300
Printed by the authority of the State of Illinois

Other CTAP Publications

The Changing Illinois Environment: Critical Trends, summary and 7-volume technical report
Illinois Land Cover, An Atlas, plus CD-ROM
Inventory of Ecologically Resource-Rich Areas in Illinois
Rock River Area Assessment, 5-volume technical report
The Rock River Country: An Inventory of the Region's Resources
Cache River Area Assessment, 5-volume technical report
The Cache River Basin: An Inventory of the Region's Resources
Mackinaw River Area Assessment, 5-volume technical report
The Mackinaw River Country: An Inventory of the Region's Resources
The Illinois Headwaters: An Inventory of the Region's Resources
Headwaters Area Assessment, 5-volume technical report
The Illinois Big Rivers: An Inventory of the Region's Resources
Big Rivers Area Assessment, 5-volume technical report
The Fox River Basin: An Inventory of the Region's Resources
Fox River Area Assessment, 5-volume technical report
The Kankakee River Valley: An Inventory of the Region's Resources
Kankakee River Area Assessment, 5-volume technical report
The Kishwaukee River Basin: An Inventory of the Region's Resources
Kishwaukee River Area Assessment, 5-volume technical report
Embarras River Area Assessment, 5-volume technical report
Upper Des Plaines River Area Assessment, 5-volume technical report
Annual Report 1997, Illinois EcoWatch
Stream Monitoring Manual, Illinois RiverWatch
Forest Monitoring Manual, Illinois ForestWatch
Illinois Geographic Information System, CD-ROM of digital geospatial data

All CTAP and Ecosystems Program documents are available from the DNR Clearinghouse at (217) 782-7498 or TDD (217) 782-9175. Selected publications are also available on the World Wide Web at http://dnr.state.il.us/ctap/ctaphome.htm, or . http://dnr.state.il.us/c2000/manage/partner.htm, as well as on the EcoForum Bulletin Board at 1 (800) 528-5486 or (217) 782-8447.

For more information about CTAP, call (217) 524-0500 or e-mail at ctap2@dnrmail.state.il.us; for information on the Ecosystems Program call (217) 782-7940 or e-mail at ecoprog@dnrmail.state.il.us.

About This Report

The Illinois River Bluffs Area Assessment examines an area in west-central Illinois that includes parts of the upper and lower Illinois River watersheds from the vicinity of Hennepin southward to East Peoria. Because significant natural community and species diversity is found in the area, it has been designated a state Resource Rich Area.[1]

This report is part of a series of reports on areas of Illinois where a public-private partnership has been formed. These assessments provide information on the natural and human resources of the areas as a basis for managing and improving their ecosystems. The determination of resource rich areas and development of ecosystem-based information and management programs in Illinois are the result of three processes -- the Critical Trends Assessment Program, the Conservation Congress, and the Water Resources and Land Use Priorities Task Force.

Background

The Critical Trends Assessment Program (CTAP) documents changes in ecological conditions. In 1994, using existing information, the program provided a baseline of ecological conditions.[2] Three conclusions were drawn from the baseline investigation:

1. the emission and discharge of regulated pollutants over the past 20 years has declined, in some cases dramatically,
2. existing data suggest that the condition of natural ecosystems in Illinois is rapidly declining as a result of fragmentation and continued stress, and
3. data designed to monitor compliance with environmental regulations or the status of individual species are not sufficient to assess ecosystem health statewide.

Based on these findings, CTAP has begun to develop methods to systematically monitor ecological conditions and provide information for ecosystem-based management. Five components make up this effort:

1. identify resource rich areas,
2. conduct regional assessments,
3. publish an atlas and inventory of Illinois landcover,
4. train volunteers to collect ecological indicator data, and
5. develop an educational science curriculum which incorporates data collection

---

[1] See *Inventory of Resource Rich Areas in Illinois: An Evaluation of Ecological Resources.*
[2] See *The Changing Illinois Environment: Critical Trends*, summary report and volumes 1-7.

At the same time that CTAP was publishing its baseline findings, the Illinois Conservation Congress and the Water Resources and Land Use Priorities Task Force were presenting their respective findings. These groups agreed with the CTAP conclusion that the state's ecosystems were declining. Better stewardship was needed, and they determined that a voluntary, incentive-based, grassroots approach would be the most appropriate, one that recognized the inter-relatedness of economic development and natural resource protection and enhancement.

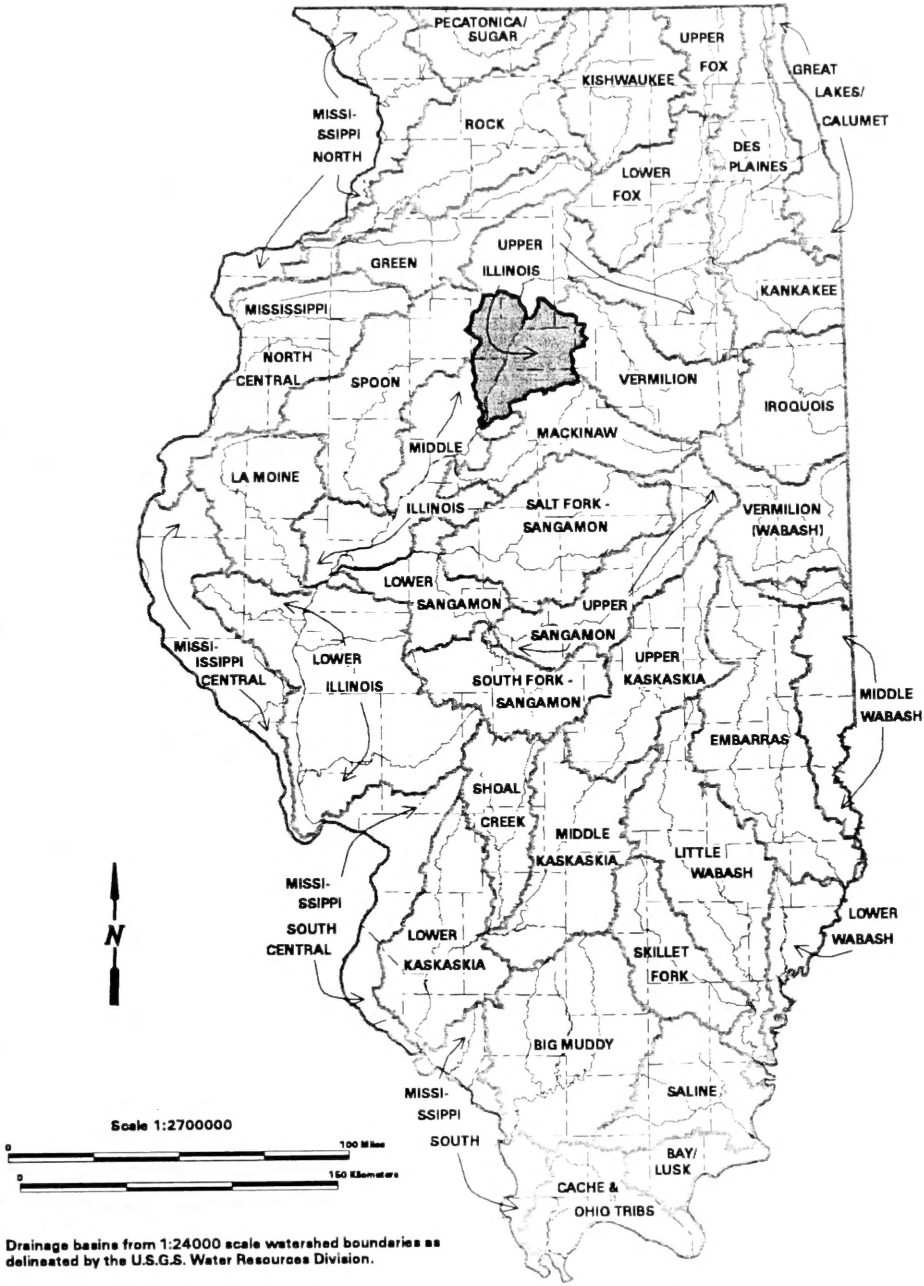
From the three initiatives was born Conservation 2000, a six-year program to begin reversing ecosystem degradation, primarily through the Ecosystems Program, a cooperative process of public-private partnerships that are intended to merge natural resource stewardship with economic and recreational development. To achieve this goal, the program will provide financial incentives and technical assistance to private landowners. The Rock River and Cache River were designated as the first Ecosystem Partnership areas.

At the same time, CTAP identified 30 Resource Rich Areas (RRAs) throughout the state. In RRAs where Ecosystem Partnerships have been formed, CTAP is providing an assessment of the area, drawing from ecological and socio-economic databases to give an overview of the region's resources -- geologic, edaphic, hydrologic, biotic, and socio-economic. Although several of the analyses are somewhat restricted by spatial and/or temporal limitations of the data, they help to identify information gaps and additional opportunities and constraints to establishing long-term monitoring programs in the partnership areas.

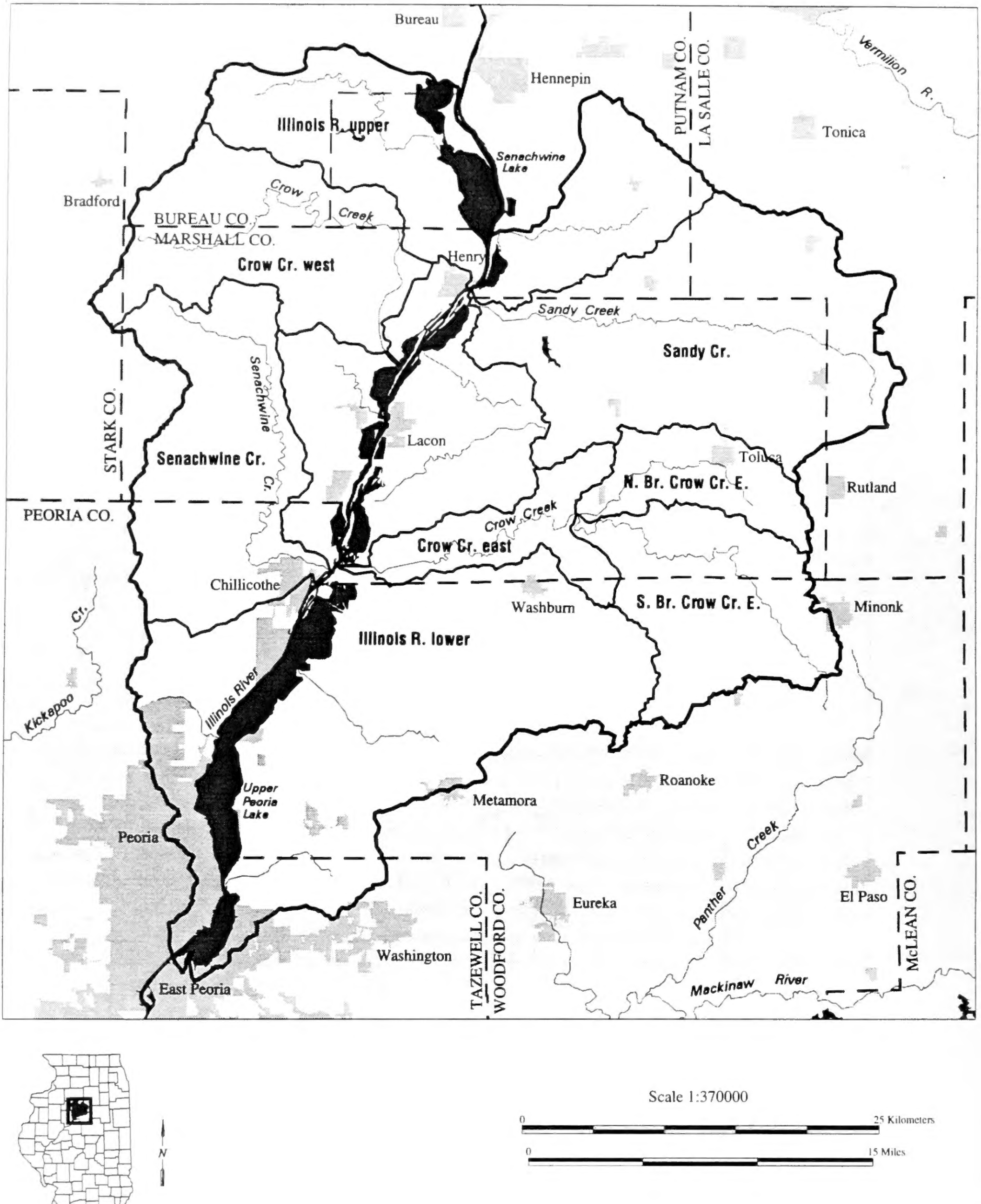
The Illinois River Bluffs Assessment

The Illinois River Bluffs Assessment covers an area of about 560,871 acres in west central Illinois. It includes parts of the upper and lower Illinois River watersheds from the vicinity of Hennepin southward to East Peoria. Counties encompassed in this assessment include most of Marshall and Woodford counties as well as small portions of Stark, Bureau, La Salle, Tazewell, Putnam, and Peoria counties. In addition to containing a portion of the Illinois River Drainage basin (Illinois River upper and lower), this area also encompasses portions of the Crow Creek west, Sandy Creek, Senachwine Creek and Crow Creek east drainage basins as identified by the Illinois Environmental Protection Agency. Three of the sub-basins in this assessment area (Illinois River lower, Senachwine Creek, and Crow Creek east) were designated as "Resource Rich Areas" (a total of 277,847 acres) because they contain significant natural community diversity. The Illinois River Bluffs Ecosystem Partnership was subsequently formed around this core area of high quality ecological resources.

This assessment is comprised of five volumes. In Volume 1, *Geology* discusses the geology, soils, and minerals in the assessment area. Volume 2, *Water Resources*, discusses the surface and groundwater resources and Volume 3, *Living Resources*, describes the natural vegetation communities and the fauna of the region. Volume 4



Major Drainage Basins of Illinois and Location of the Illinois River Bluffs Assessment Area



Subbasins in the Illinois River Bluffs Assessment Area. Subbasin boundaries depicted are those determined by the Illinois Environmental Protection Agency.

contains three parts: Part I, *Socio-Economic Profile*, discusses the demographics, infrastructure, and economy of the area, focusing on the three counties with the greatest amount of land in the area — Marshall, Peoria and Woodford; Part II, *Environmental Quality*, discusses air and water quality, and hazardous and toxic waste generation and management in the area; and Part III, *Archaeological Resources*, identifies and assesses the archaeological sites, ranging from the Paleoindian Prehistoric (B.C. 10,000) to the Historic (A.D. 1650), known in the assessment watershed. Volume 5, *Early Accounts of the Ecology of the Illinois River Bluffs Area*, describes the ecology of the area as recorded by historical writings of explorers, pioneers, early visitors and early historians.

Contributors

Project Coordinator .... Nani Bhowmik

Maps .... Robert Sinclair, Mark Varner

Editor .... Christopher Wellner

Introduction

Rivers and Streams, Lakes, Physiography .... H. Vernon Knapp

Wetlands .... Michael Miller, Liane Suloway, Laura Keefer*

Land Use .... Laura Keefer

Climate and Trends in Climate .... James Angel, Wayne Armstrong

Streamflow .... H. Vernon Knapp, Gana Ramamurthy, Kenneth Nichols

Erosion and Sedimentation .... Misganaw Demissie, Renjie Xia, William Bogner

Water Use and Availability

Ground-Water Resources .... Kenneth Hlinka, John Blomberg, Kay Charles

Surface Water Resources .... H. Vernon Knapp

Ground-Water Quality .... Kenneth Hlinka, John Blomberg, Thomas Holm

---

* Contributor Affiliations: Michael Miller, Illinois State Geological Survey; Liane Suloway, Illinois Natural History Survey; Laura Keefer, Illinois State Water Survey.

Table of Contents

List of Figures

Introduction

Climate and Trends in Climate

Streamflow

Erosion and Sedimentation

Water Use and Availability

List of Tables

Introduction

Climate and Trends in Climate

Streamflow

Erosion and Sedimentation

Water Use and Availability

Ground-Water Quality

Introduction

The Illinois River Bluffs area is comprised of a 33-mile stretch along the Illinois River, between river miles 166 and 199, and the watershed areas of all tributaries that drain into the river in this reach. This portion of the river stretches from the city of Peoria upstream to Senachwine Lake, north of the town of Henry. The Illinois River valley in this region is broad, gently sloping, and contains a number of backwater lakes which provide both a substantial recreation benefit to the region and habitat for wildlife, fish, and waterfowl. Foremost of these is Peoria Lake, which is the largest and deepest bottomland lake in the Illinois River Valley. The river valley in this reach is bounded by steeply-sloping bluffs, typically rise over 150 feet above the valley floor, for which the region is named. Progressively farther from the river, in the tributary watersheds, are upland areas that are gently to moderately rolling. The total area of the bottomlands, bluffs, and tributary watershed measures 876 square miles, and includes portions of seven counties: Peoria, Tazewell, Woodford, Marshall, Putnam, La Salle, and Bureau. Figure 1 shows the Illinois River Bluffs area and its major streams. Mean annual precipitation for the river basin is about 36.25 inches.

Rivers and Streams

There are about 1,450 miles of rivers and streams in the Illinois River Bluffs area. Larger streams (those with watersheds greater than 10 square miles) account for about 25% of this total, or approximately 358 river miles.

The total drainage area of the Illinois River at the downstream end of the Bluffs area is 14,165 square miles, and represents 49% of the entire Illinois River basin. The upper Illinois River basin extends upstream to encompass almost all of northeastern Illinois, including most of the Chicago metropolitan area, and portions of southeastern Wisconsin and northwestern Indiana. Much of the Illinois River upstream of the Bluffs area flows through a fairly narrow channel having a moderate channel slope; in the Bluffs area, however, the river's slope becomes very flat and the river bottomlands broaden, in some locations to more than three miles wide. The river's channel is naturally constricted at Peoria, where the Bloomington Moraine crosses the river, creating a series of broad shallow pools on the river. The Peoria Lock and Dam, 8 miles downstream, adds an additional control that stabilizes water levels on the river during low and medium flows.

The Illinois River has four major tributaries in the area, Sandy Creek, Crow Creek (East), Crow Creek (West), and Senachwine Creek. These streams are shown in Figure 1. Additional tributaries having drainage areas in excess of 10 square miles are listed in Table 1.

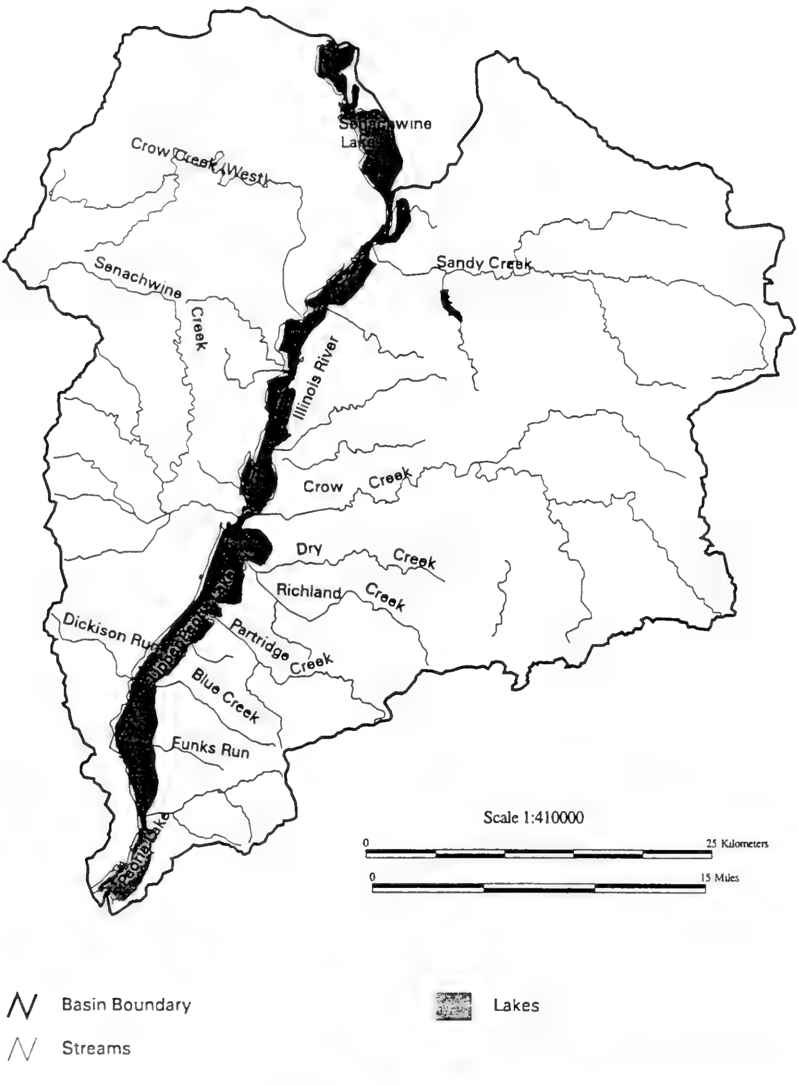


Figure 1. Major Streams and Lakes in the Illinois River Bluffs

Table 1. Tributaries in the Illinois River Bluffs Area

Stream	Counties	Drainage area (sq. mi.)	Illinois River Mile
Tenmile Creek	Tazewell, Woodford	17.6	166.2
Blue Creek	Woodford	10.5	173.1
Partridge Creek	Woodford	28.0	177.3
Richland Creek	Woodford	47.0	180.4
Snag Creek	Woodford	40.6	181.1
Crow Creek (East)	Marshall, Woodford	130.0	182.2
Strawn Creek	Marshall	10.2	185.5
Senachwine Creek (South)	Peoria, Marshall	90.0	181.6
Gimlet Creek	Marshall	5.7	189.1
Crow Creek (West)	Marshall, Putnam, Bureau	82.0	191.6
Sandy Creek	Marshall, LaSalle	146.0	196.2
Clear Creek	Putnam	38.5	197.0
Senachwine Creek (North)	Putnam	38.0	199.0

The two largest tributaries, Sandy Creek and Crow Creek (East), originate in eastern Marshall and Woodford Counties, in an area typified by flat to gently rolling plains. The stream slopes in this region are moderate, averaging about 2.5 feet per mile (ft/mi). The highest land elevations in this area are generally about 700 to 750 feet above mean sea level (msl). Figure 2 illustrates the channel slope of some tributaries in this area. As Crow Creek flows west, the channel slope increases to a maximum of 15 ft/mi as the stream flows past the bluff line down to the Illinois River.

In contrast is Crow Creek (West), which originates in Bureau County and flows through western Putnam and Marshall Counties, through the hilly topography of the Bloomington Moraine. The headwaters on the western side of the region is almost 100 feet higher than that on the other side of the Illinois River, and the channel slope is almost 20 ft/mi. The channel slope decreases downstream, but always remains comparatively steep (above 10 ft/mi). The profile of Strawn Creek is typical of the many small streams which originate near the bluff line, cutting through the steep slopes to the Illinois River bottomlands. The maximum channel slope for Strawn Creek exceeds 30 ft/mi.

The streams in the Illinois River Bluffs area are generally well developed and incised so as not to require channelization. Most of the channelized stream segments are near the headwaters of Crow Creek (East) and Sandy Creek, in the eastern fringe of the region (Mattingly and Herricks, 1991).

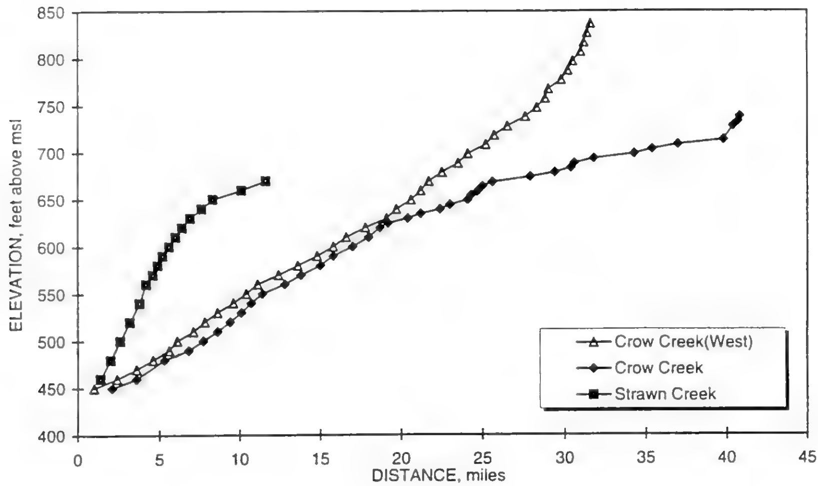


Figure 2. Stream Profiles for Three Tributaries in the Illinois River Bluffs Area

Lakes

The constriction of the Illinois River at Peoria, along with the overall low gradient of the river, creates a series of backwater and flow-through lakes throughout the Bluffs area. These lakes and the entire bottomland area along the river are the vestiges of a larger river system that occupied the Illinois River Valley during the last glacial period.

Table 2 lists the largest of these bottomland lakes. The total water surface area of the river and these lakes is approximately 32,000 acres, or 50 square miles. Peoria Lake, located between river miles 166 and 182, is the largest of these lakes and accounts for almost half of the total surface area. A well-known concern for the lakes is sedimentation and volume loss, described later, and its impact on the ultimate viability of the bottomland lakes.

Also listed in Table 2 are the region's two largest impounding reservoirs, Thunderbird Lake and Wildwood Lake, which are used primarily for recreation. In addition, there are 82 other smaller lakes in the Illinois River Bluffs area. Forty-five of these smaller lakes are located in the Illinois River bottomlands, with the five largest being gravel pit lakes. The remaining lakes are small impounding reservoirs with surface areas less than 30 acres.

Table 2. Significant Lakes and Reservoirs in the Illinois River Bluffs Area

Name	County	Surface area (acres)	Type
Peoria Lake	Peoria	14,000	Backwater
Goose Lake	Woodford	3,000	Backwater
Douglas Lake	Marshall	973	Backwater
Goose Lake/Weis Lake	Marshall	1,300	Backwater
Babb Slough/Sawyer Slough	Marshall	1,875	Backwater
Billsbach Lake	Marshall	1,015	Backwater
Sawmill Lake	Putnam	630	Backwater
Senachwine Lake	Putnam	3,325	Backwater
Goose Lake	Putnam	2,360	Backwater
Thunderbird Lake	Putnam	114	Stream Impoundment
Wildwood Lake	Marshall	197	Stream Impoundment

Wetlands

Wetlands are an important part of our landscape because they provide critical habitat for many plants and animals and serve an important role in mitigating the effects of storm flow in streams. They are also government-regulated landscape features under Section 404 of the Clean Water Act. In general, wetlands are a transition zone between dry uplands and open water; however, open-water areas in many upland depressional wetlands are dry at the surface for significant portions of the year.

The Illinois River Bluffs area has about 5.9% (33,206 acres) of its total area in wetlands (Table 3). Approximately 14% (15,534 acres) of these wetlands are in the river valley and are classified as lacustrine or shallow lake wetlands. Approximately 35% (11,595 acres) of the total wetlands exist in stream corridors and are classed as bottomland forest or riverine wetlands. (For wetland categories, see the table describing wetland and deepwater habitat in Volume 3: Living Resources.)

Table 3. Wetlands in the Illinois River Bluffs Area

	Subbasin		Wetlands		
Subbasin name	Acres	% of area	Acres	% of subbasin	% of total wetlands
Crow Cr. E.	19,850	3.5	839.05	4.2	2.5
Crow Cr. W.	51,125	9.1	552.91	1.1	1.7
Illinois R. lower	207,848	37.1	26,443.38	12.7	79.6
Illinois R. upper	71,510	12.7	3,247.68	4.5	9.8
N. Br. Crow Cr. E.	19,479	3.5	71.73	0.4	0.2
S. Br. Crow Cr. E.	42,382	7.6	270.93	0.6	0.8
Sandy Cr.	91,089	16.2	443.52	0.5	1.3
Senachwine Cr.	57,583	10.3	1,336.71	2.3	4.0
Total	560,866	100.0	33,205.91	5.9	100.0

The hydrogeology of wetlands allows water to accumulate in them longer than in the surrounding landscape, with far-reaching consequences for the natural environment. Wetland sites become the locus of organisms that require or can tolerate moisture for extended periods of time, and the wetland itself becomes the breeding habitat and nursery for many organisms that require water for early development. Plants that can tolerate moist conditions (hydrophytes) can exist in these areas, whereas upland plants cannot successfully compete for existence. Given the above conditions, the remaining wetlands in our landscape are refuges for many plants and animals that were once widespread but are now restricted to existing wetland areas.

The configuration of wetlands enables them to retain excess rainwater, extending the time the water spends on the upland area. The effect of this retention on the basin is to delay the delivery of water to the main stream. This decreases the peak discharges of storm flow or floods, thus reducing flood damages and the resulting costs. It is important to realize that the destruction of wetland areas has the opposite effect, increasing peak flood flows and thereby increasing flood damages and costs.

The location of wetlands affects many day-to-day decisions because wetlands are considered "Waters of the United States" (Clean Water Act) and are protected by various legislation at the local, state, and federal levels (for example, the Rivers and Harbors Act of 1899, Section 10; the Clean Water Act; and the Illinois Interagency Wetlands Act of 1989). Activities by government, private enterprise, and individual citizens are subject to regulations administered by the U.S. Army Corps of Engineers. Under a Memorandum of Agreement between federal regulatory agencies with jurisdiction over wetlands, the Natural Resources Conservation Service takes the lead in regulating wetland issues for agricultural land, and the U.S. Army Corps of Engineers takes the lead for all nonagricultural lands.

In contexts where wetland resources are an issue, the location and acreage of a wetland will be information required by any regulatory agency, whether local, state, or federal. Currently, there are two general sources of wetland location information for Illinois: the National Wetland Inventory (NWI), completed in 1980, and *Illinois Land Cover, an Atlas* (*ILCA*) by the Illinois Department of Natural Resources (1996). The State of Illinois used the NWI information to publish the *Wetland Resources of Illinois: An Analysis and Atlas* (Suloway and Hubbell, 1994). While this atlas is not of suitable scale for landowners or government agencies to use for individual wetland locations, it can be used by agencies or groups that consider wetlands in an administrative or general government manner and focus on acreage and not individual wetland boundaries.

The NWI program involved identifying wetlands on aerial photographs of 1:58,000 scale and publishing maps of this information using USGS 1:24,000-scale topographic quadrangle maps as the base. NWI quadrangle maps for the Illinois River Bluffs area are shown in Figure 3. Individual quadrangles can be purchased from the following address (see page 7).

Center for Governmental Studies
Wetland Map Sales
Northern Illinois University
De Kalb, IL 60115
Telephone: (815) 753-1901

Digital data by quadrangle are available from the NWI Web site: www.nwi.fws.gov.

The ILCA inventory used Landsat Thematic Mapper satellite data as the primary source for interpretation. National Aerial Photography Program photographs verified the land cover classification and helped ensure consistency from area to area within Illinois. The ILCA and companion compact disc can be purchased from:

Illinois Department of Natural Resources
524 South Second Street
Lincoln Tower Plaza
Springfield, IL 62701-1787
Telephone: (217) 524-0500
E-mail: ctap2@dnrmail.state.il.us
Web site: http://dnr.state.il.us/ctap/ctaphome.htm

Although the ILCA and NWI programs were not meant for regulatory purposes, they are the only state or regional wetland map resources available and are the logical sources for beginning a wetland assessment. The presence or absence of wetlands as represented by the wetland maps is not certified by either the ILCA or the NWI mapping program. Figure 4, taken from the Chauncey Quadrangle in the Illinois River Bluffs area, exemplifies the information that can be expected from NWI maps.

In some areas with intense economic development and significant wetland acreage, the NWI maps have been redone or updated for use in designating or locating wetland areas. Whatever the source of wetland map information, the user should be aware that this information is a general indication of wetland locations, and the boundaries and exact locations should be field-verified by persons trained or certified in wetland delineation.

Given the limitations of most existing wetland maps, more complete information can be obtained by comparing mapped wetlands with other regional attributes such as shallow aquifers, subsurface geology, and placement in the landscape. When these comparisons show consistent regional patterns (for example, placement in the landscape or correlation with a particular geologic material), any parcels of land with similar landscape positions or geologic materials can be considered potential wetland sites even if maps do not show them as wet.

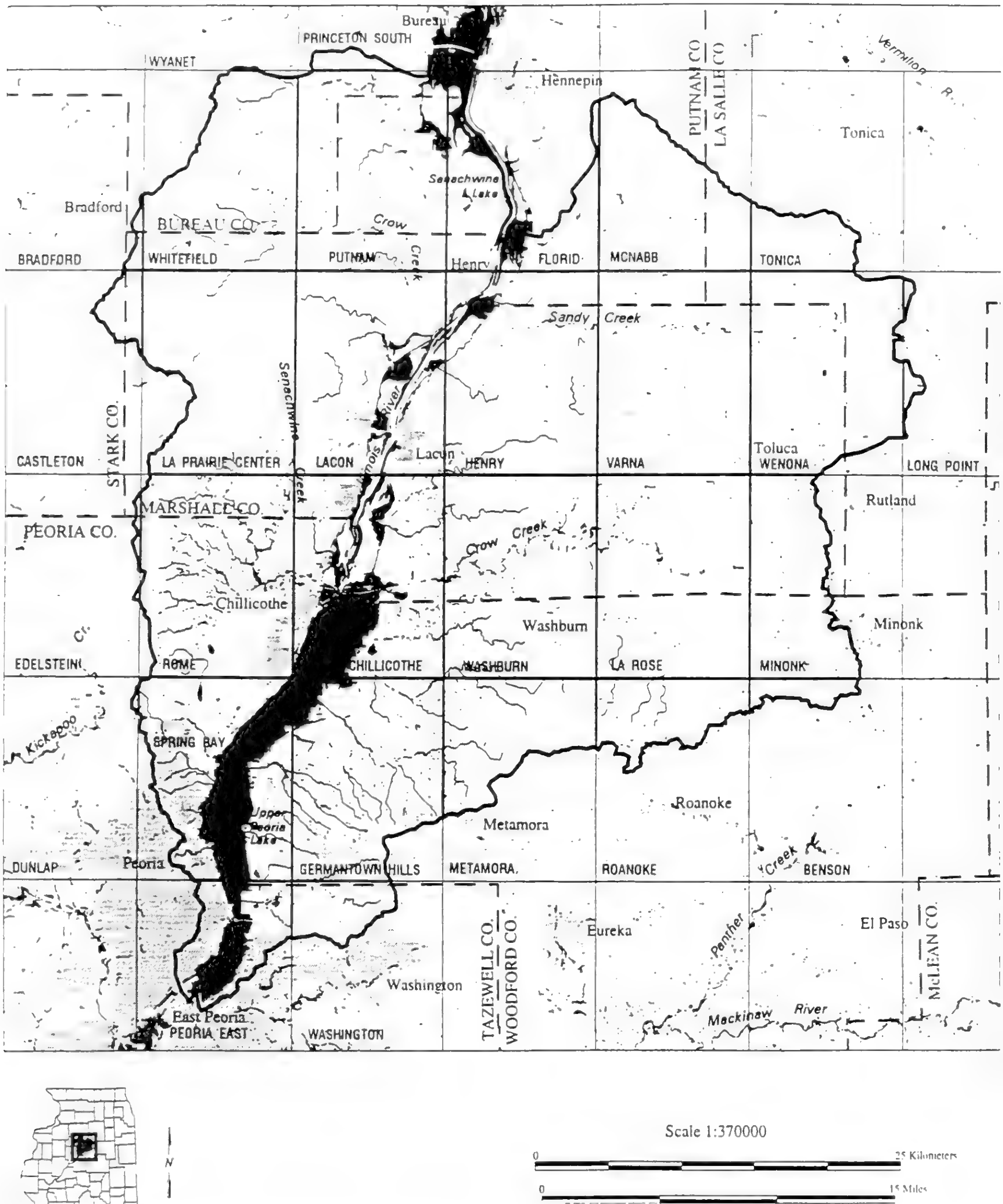


Figure 3. Wetlands from the National Wetlands Inventory and quadrangle map boundaries for the Illinois River Bluffs assessment area. The inset area is depicted in the following figure

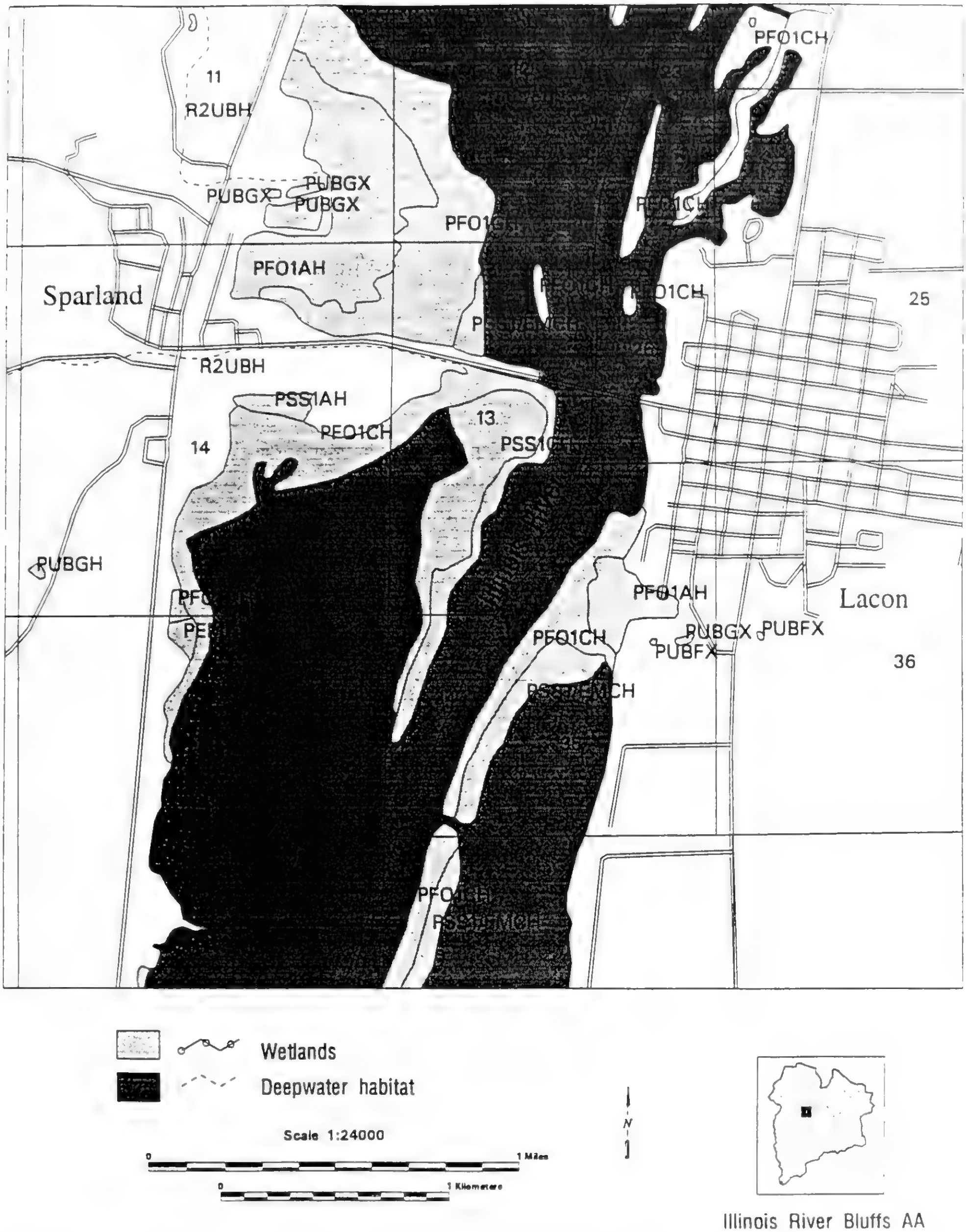


Figure 4. National Wetlands Inventory information from the Lacon 7.5-minute quadrangle map showing wetlands, deepwater habitat, and NWI codes

Physiography

The Illinois River Bluffs area is located entirely within the physiographic division termed the Bloomington Ridged Till Plain, as defined by Leighton et al. (1948). The Bloomington Ridged Till Plain stretches across much of east-central Illinois, from just west of Peoria to the Illinois-Indiana border. The topography of this region was created primarily through the deposition of glacial till during the most recent Wisconsin Episode of glaciation. The area is typified by extensive reaches of flat to gently rolling plains, interrupted up by a series of end moraines, which create broad ridges of low relief. The topography of eastern half of the Illinois River Bluffs area is most characteristic of this physiographic division. The local relief, or change in land elevation, in this eastern half is relatively small, with upland elevations typically in the range of 650 to 700 feet.

The western half of the Bluffs area is hilly and generally atypical of its physiographic division. This hilly character is present primarily because the Bloomington Moraine crosses the western half of the Bluffs region and provides additional relief to the region's topography. Land elevations are typically higher than those in the eastern half, with the highest elevation in the Bluffs area, 950 feet, occurring in southern Bureau County.

The Illinois River Valley is the remnant of a much larger glacial river system that included drainage from portions of what is now the Upper Mississippi River basin. This larger drainage system carried significantly larger amounts of flow, including that from glacial outwash, as was able to carve out the broad valley that the Illinois River now occupies. Within the Illinois River Bluffs area, the width of the valley ranges from 1.5 miles at its narrowest point near Peoria to over 7 miles. The valley constriction near Peoria occurs where the Bloomington and Shelbyville Moraines converge and cross the river. In cutting through the upland areas of the region, the Illinois River Valley has created significant amount of relief. The bluffs rise steeply to 150 feet above the valley floor, which is broad and gently sloping. Tributary streams to the Illinois River have also downcutted through the bluff line to create additional steep slopes that add relief to the region.

Table 4 shows the distribution of land slopes for Marshall County, which spans the Illinois River Bluffs area. Over seven percent of the land area has slopes greater than 30 percent, being located along or near the river bluffs. Over sixty percent of the land surface is nearly level or gently sloping, and is primarily located either in the Illinois River valley and in the upland areas in the eastern side of the county.

Table 4. Distribution of Land Slopes for Marshall County

Slope	Percent of land in slope category
0 - 2 %	30.3
2 - 4	33.2
4 - 7	20.4
7 - 12	3.4
12 - 18	2.1
18 - 30	3.2
> 30	7.3

Source: Runge et al. (1969)

Land Use

Agriculture is a major land use in the eight counties (Bureau, LaSalle, Marshall, Peoria, Putnam, Stark, Tazewell, and Woodford) in the Illinois River Bluffs area. The Illinois Department of Agriculture, Illinois Agricultural Statistics (IAS) data indicate that in 1995 agriculture acreage accounted for approximately 31% of the total surface area in the Illinois River Bluffs assessment area and has increased only 4% from 341,650 acres in 1925 to 370,008 acres in 1995. Figure 5 shows the changes in the harvested acres of selected crops in the basin from 1925 to 1995.

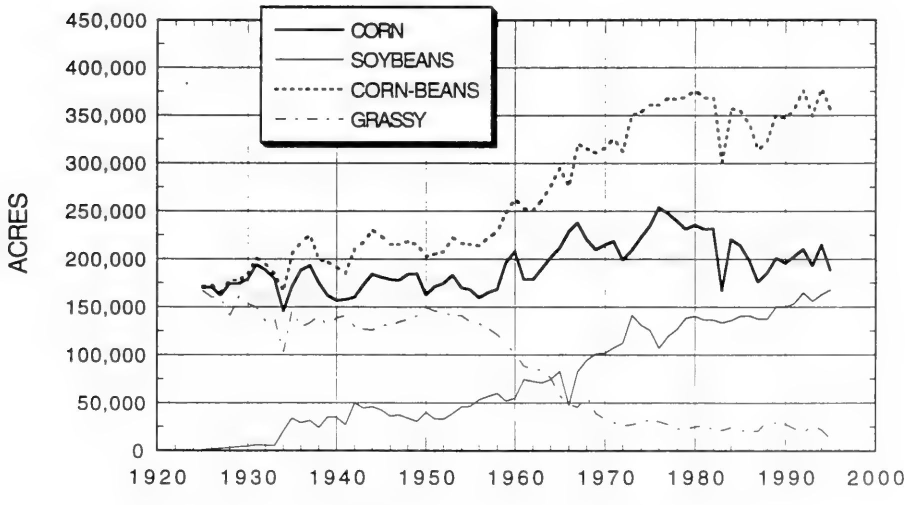


Figure 5. Acreages of Selected Crops in the Illinois River Bluffs Area Based on IAS Data

In 1925 the dominant crops were grassy crops (wheat, oats, and hay) and corn, accounting for 99% of the agricultural crops grown in the basin (170,883 acres for corn and 167,275 for grassy crops). Corn acreage has remained fairly steady over time, increasing only slightly to levels above 250,000 acres in 1976, with a significant drop (approximately 30%) in 1983 to 167,192 acres. In 1925 soybeans were confined to little over 1000 acres; however, it steadily increased to 167,935 acres in 1995, the most acres harvested to date. The average grassy crop acreage from 1925 to 1950 was 140,000 and from this time steadily decreased to approximately 13,000 acres in 1995. The inverse relationship between soybean and grassy crop acreage is shown in figure 5, where the trends in acreage cross during 1964-66. In 1995 the dominant crops were corn and soybeans as opposed to corn and grassy crops in 1925. Ninety-six percent of crop acres harvested in the Illinois River Bluffs area is corn and soybeans (356,803 acres).

Climate and Trends in Climate

This chapter reviews climate trends in and around the Illinois River Bluffs area since the turn of the century. Climate parameters examined include annual mean temperature, the number of days with highs above or equal to 90°F, the number of days with lows below or equal to 32°F, the number of days with lows below or equal to 0°F, annual precipitation, the number of days with measurable precipitation, annual snowfall, and the number of days with measurable snowfall. Extreme weather events examined in this report are tornadoes, hail, and thunderstorms.

The Illinois River Bluffs area in north-central Illinois occupies portions of Bureau, Putnam, La Salle, Stark, Marshall, Peoria, Woodford, and Tazewell Counties. The climate of this area is typically continental, as shown by its changeable weather and the wide range of temperature extremes. Summer maximum temperatures are generally in the 80s or 90s, with lows in the 60s or 70s, while daily high temperatures in winter are generally in the 20s or 30s, with lows in the teens or 20s. Based on the latest 30-year average (1961-1990), the average first occurrence of 32°F in the fall is October 17, and the average last occurrence in the spring is April 22.

Precipitation is normally heaviest during the growing season and lightest in midwinter. Thunderstorms and associated heavy showers are the major source of growing season precipitation, and they can produce gusty winds, hail, and tornadoes. The months with the most snowfall are November, December, January, February, March, and April. However, snowfalls have occurred as early as October and as late as May. Heavy snowfalls rarely exceed 12 inches.

The climate data used in the following discussions originate at Peoria, Illinois (Peoria County), which houses the National Weather Service (NWS) Coop site with the longest record (1901-1996) near the southern portion of the basin. Supportive data and analyses for nearby Illinois sites can be found in reports by the Illinois Department of Energy and Natural Resources (1994) and Changnon (1984).

Temperature

The mean January maximum temperature is 30°F and the minimum is 13°F, whereas the mean July maximum and minimum temperatures are 86°F and 65°F, respectively (Table 5). The mean annual temperature at Peoria is 50.7°F. The warmest year of record was 1901, with an average of 57.2°F, while the coldest was 1917, with an average of 47.8°F.

Table 5. Temperature Summary for Peoria
(Averages are from 1961-1990 and extremes are from 1901-1996. Temperatures are in °F)

Month	Avg. high	Avg. low	Record high (year)	Record low (year)	# of days with high ≥90°F	# of days with low ≤32°F	# of days with low ≤ 0°F
January	29.9	13.2	71 (1909)	-25 (1977)	0	28	4.4
February	34.9	17.7	74 (1932)	-26 (1905)	0	25	2.6
March	48.1	29.8	87 (1907)	-11 (1943)	0	19	0.2
April	62.0	40.8	92 (1930)	14 (1920)	0.1	5.8	0
May	72.8	50.9	104 (1934)	25 (1966)	1.0	0.4	0
June	82.2	60.7	105 (1934)	39 (1945)	5.6	0	0
July	85.7	65.4	113 (1936)	46 (1911)	9.8	0	0
August	83.1	63.1	106 (1936)	41 (1910)	7.2	0	0
September	76.9	55.2	102 (1939)	24 (1942)	2.8	0.1	0
October	64.8	43.1	92 (1922)	7 (1925)	0.1	3.8	0
November	49.8	32.5	81 (1937)	-2 (1977)	0	16	0.1
December	34.6	19.3	71 (1970)	-24 (1924)	0	26	2.2

Although there is a great deal of year-to-year variability, mean annual temperatures at Peoria show a warming trend from 1901 to 1930, followed by a cooling trend until 1960, warming again through 1996 (Figure 6)

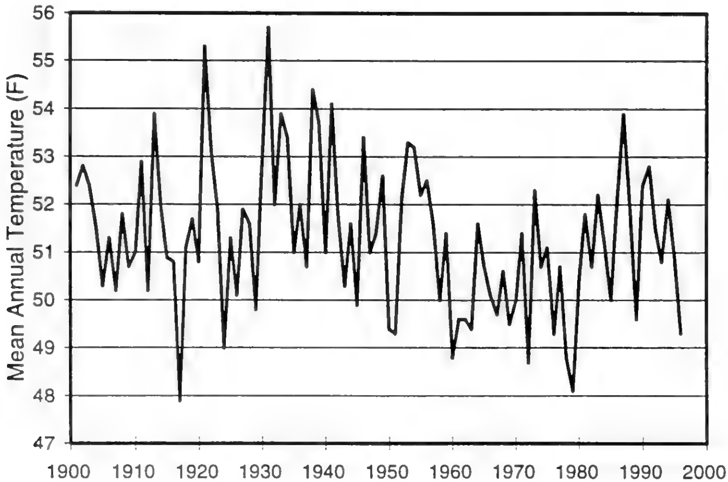


Figure 6. Mean Annual Temperature for Peoria, 1901-1996

Examination of mean temperatures over time is one way to clarify trends. The NWS has adopted 30-year averages, ending at the beginning of the latest new decade, to represent climate "normals." These averages filter out some of the smaller scale features and yet retain the character of the longer term trends. Consecutive, overlapping "normals" for the last seven 30-year periods at Charleston are presented in Table 6. The consecutive means demonstrate the warming trend through the 1931-1960 period, followed by a cooling trend through the 1961-1990 period.

Table 6. Average Annual Temperature during Consecutive 30-Year Periods

Averaging period	Average temperature (°F)
1901-1930	51.4
1911-1940	51.8
1921-1950	51.9
1931-1960	51.9
1941-1970	51.0
1951-1980	50.5
1961-1990	50.5

The frequency of extreme events sometimes conveys a clearer picture of trends than mean values. The annual number of days with temperatures equal to or above 90°F is shown in Figure 7. Not too surprisingly, this bears little resemblance to annual temperature (Figure 6), because the number of days with temperatures above 90°F represents only the high summer temperature extremes. Figure 7 shows an increase through 1938, followed by a slow decline through 1970, before returning to somewhat higher numbers from 1971 to 1996.

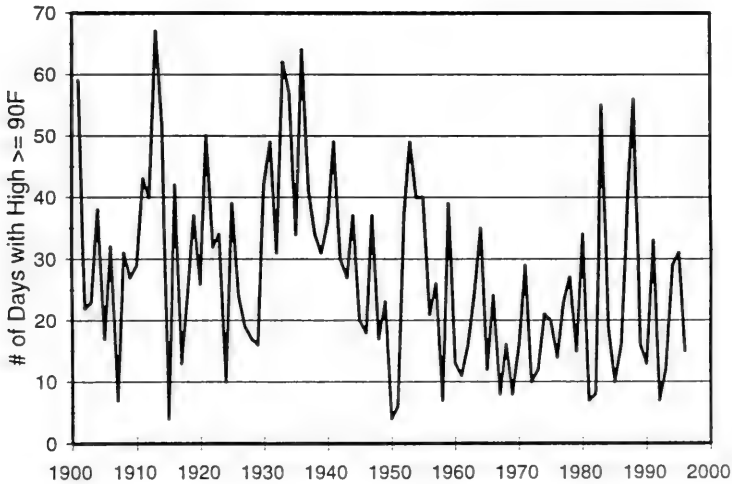


Figure 7. Annual Number of Days with Maximum Temperatures Equal to or Above 90°F at Peoria, 1901-1996

Figure 8 shows the winter frequency of daily minimum temperatures equal to or below 32°F. The frequency of such temperatures shows no trends. Figure 9 shows the number of days per year when the minimum temperature was equal to or below 0°F, beginning with the 1903-1904 winter. No long-term trends are evident. However, there is a large degree of variability from year to year.

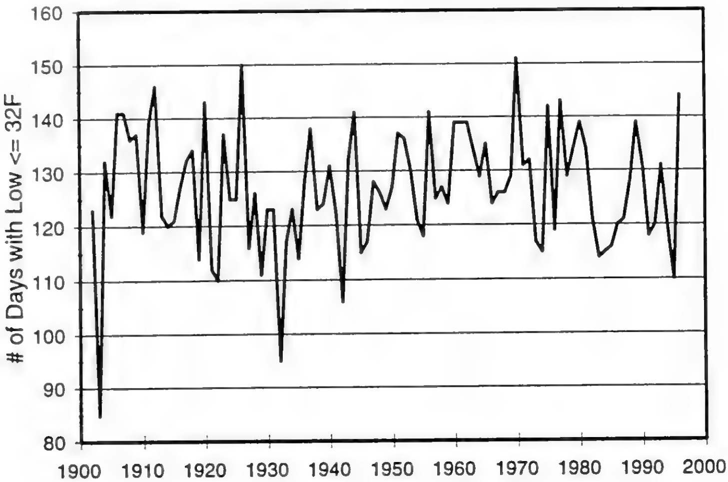


Figure 8. Annual Number of Days with Minimum Temperatures Equal to or Below 32°F at Peoria, Winters 1903-1904 to 1995-1996

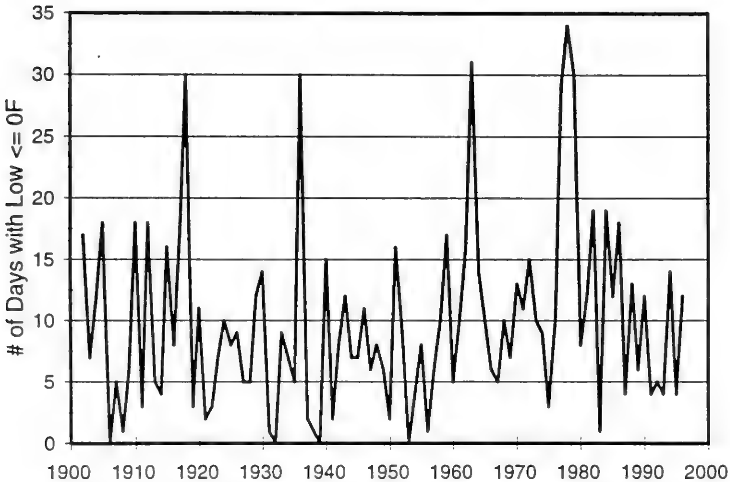


Figure 9. Annual Number of Days with Minimum Temperatures Equal to or Below 0°F at Peoria, Winters 1903-1904 to 1995-1996

Precipitation

Mean annual precipitation at Peoria is 36.25 inches, with more rainfall in the spring and summer than in fall and winter (Table 7). Late spring, summer, and early fall precipitation is primarily convective in nature, often associated with short thunderstorms (1-2 hours in duration). During the remainder of the year, precipitation is of longer duration and associated with synoptic-scale weather systems (cold fronts, occluded fronts, and low pressure systems).

The wettest year of record was 1990 (55.35 inches). The driest year was 1988 (22.17 inches).

Table 7. Precipitation Summary for Peoria
(Averages are from 1961-1990 and extremes are from 1901-1996. Precipitation is in inches.)

Month	Avg. precip.	Record high (year)	Record low (year)	Largest one-day amount (year)	Snow-fall	# of days w/ precip.
January	1.51	8.11 (1965)	0.07 (1919)	4.43 (1965)	7.3	9
February	1.42	4.95 (1942)	0.14 (1907)	2.83 (1942)	5.9	8
March	2.91	6.95 (1973)	0.40 (1958)	2.88 (1944)	3.4	11
April	3.77	8.66 (1947)	0.71 (1971)	5.06 (1950)	1.2	12
May	3.70	11.49 (1915)	0.47 (1934)	5.52 (1927)	0	12
June	3.99	11.69 (1974)	0.45 (1936)	4.74 (1911)	0	10
July	4.20	10.15 (1993)	0.33 (1988)	3.56 (1953)	0	9
August	3.10	8.61 (1955)	0.25 (1992)	4.32 (1955)	0	9
September	3.87	13.09 (1961)	0.03 (1979)	4.11 (1961)	0	9
October	2.65	10.53 (1941)	0.03 (1964)	3.62 (1969)	0.1	8
November	2.69	7.62 (1985)	0.07 (1917)	4.26 (1990)	1.9	9
December	2.44	6.34 (1949)	0.29 (1930)	2.52 (1965)	6.4	9

Annual precipitation at Peoria is shown in Figure 10. No long-term trends are evident; however, the last 10 years of data have the highest degree of variability.

The number of days per year with measurable precipitation (i.e., more than a trace) is shown in Figure 11. No trend is evident from 1901 to 1960. From 1961 to 1996, the variability in the number of days has increased dramatically. The much lower values in the first few years of the record may be due to a change in exposure, location, or observer. The annual precipitation (Figure 10) shows no such pattern, suggesting that the changes shown in Figure 11 mainly impact the very light precipitation events. Precipitation is more frequent during summer months than during winter months.

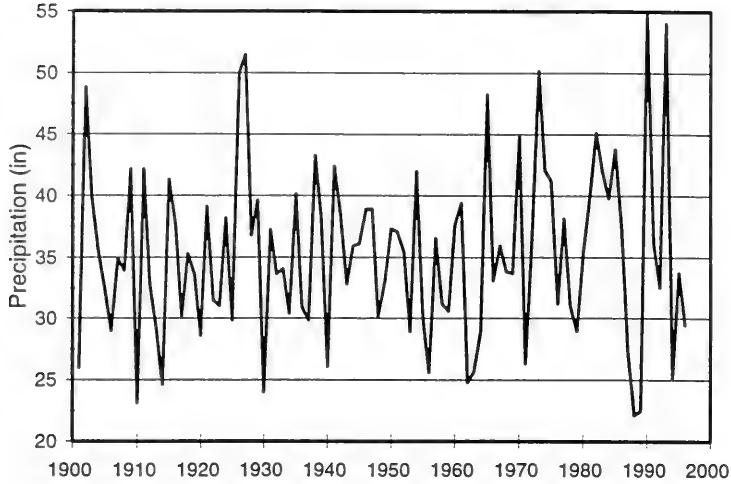


Figure 10. Annual Precipitation at Peoria, 1896-1995

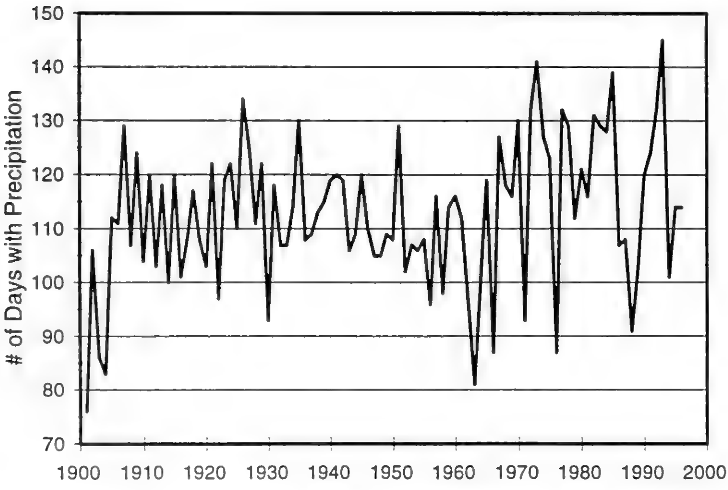


Figure 11. Annual Number of Days with Measurable Precipitation at Peoria, 1901-1996

Average winter snowfall in Peoria is 21.6 inches, with great year-to-year variability. The most snowfall during any one winter was 52.3 inches in 1977-1978, and the least was only 5.8 inches in 1916-1917. Figure 12 shows snowfall from winter 1903-1904 through winter 1995-1996. A similar upward trend was evident through the mid 1980s, followed by a slight decline through the winter of 1995-1996.

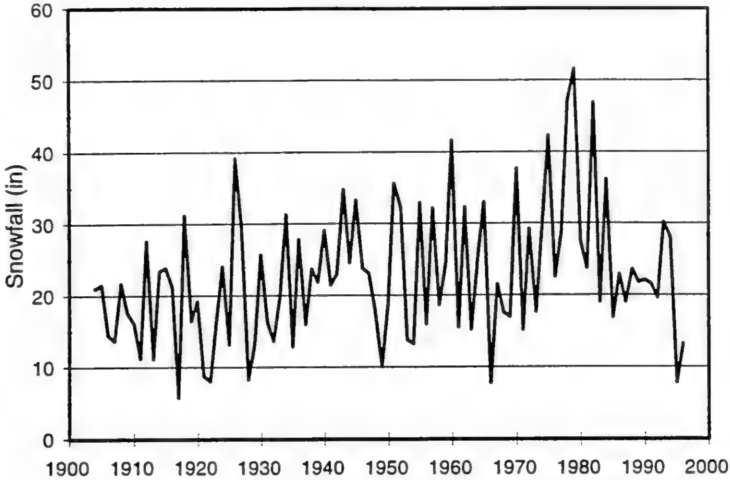


Figure 12. Annual Snowfall at Peoria, Winters 1903-1904 to 1995-1996

Figure 13 shows the number of days each winter with snowfall, from 1948-1949 through 1995-1996. The number of days with snow shows a somewhat different pattern than that for total snowfall with increases through 1966-1967, followed by decreases through 1995-1996. A snowfall of more than 6 inches occurs about once a year. Snow cover is frequently experienced at Peoria, lasting from a few days at a time to three months.

Precipitation Deficits and Excesses

Following are the driest years in the Illinois River Bluffs area in terms of annual precipitation shortfall, starting with the driest: 1988, 1989, 1910, 1930, 1914, 1962, 1994, 1956, 1963, and 1901. Driest summer seasons (June, July, and August) in the basin include: 1988, 1936, 1910, 1922, 1930, 1991, 1912, 1920, 1914, and 1933. Significantly above average precipitation fell at Peoria in 1990, 1993, 1927, 1973, 1926, 1902, 1965, 1982, 1970, and 1985. No single decade dominated in terms of years with excessive precipitation.

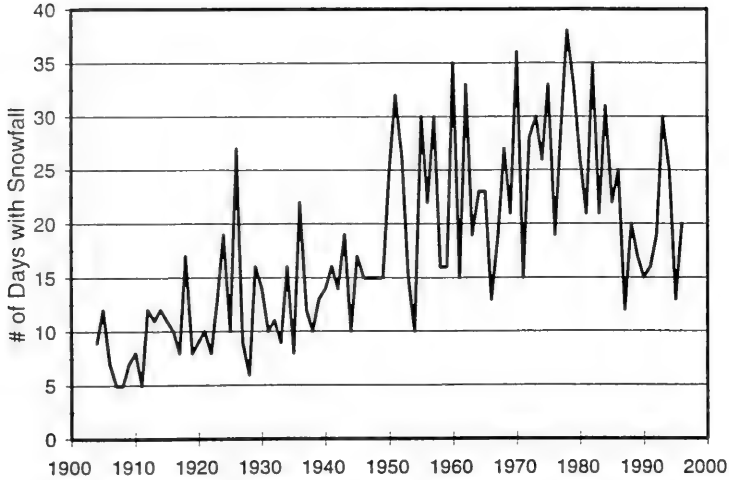


Figure 13. Annual Number of Days with Measurable Snowfall at Peoria, Winters 1903-1904 to 1995-1996

Severe Weather

Tornadoes

Although tornadoes are not uncommon in Illinois, most people do not expect to be affected directly by one, even if they live in the state for a lifetime. This is because tornadoes are generally only one-quarter mile in diameter, travel at roughly 30 miles per hour for only 15-20 minutes, and then dissipate, affecting a total area less than 2 square miles. Since Illinois observes an average of 28 tornadoes a year (though the actual number varies from fewer than ten to almost 100 during the last 35 years), the total area directly affected by tornadoes annually is only about 55 square miles, 0.1% the total area of the state. Even with 96 tornadoes reported in Illinois in 1974 (the greatest number reported in the last 30 years), the affected area was only about 0.3% the total area of the state. These numbers do not diminish the effect on those experiencing property damage, injury, or worse, but they demonstrate the extremely low probability of direct impact at any single location.

The most recent study on tornadoes in Illinois examined events from 1955 to 1986 and found no apparent trend in tornado frequency or intensity (Wendland and Guinan 1988). On average, the Illinois River Bluffs area experiences about one tornado every three years.

Hail

Hail events are somewhat rare and typically affect a very small area (from a single farm field up to a few square miles). Unfortunately, very few NWS Coop sites measure hail. The combination of small, infrequent events being measured by a sparse climate network makes for very few reliable, long-term records of these events, particularly for large areas.

Based on Changnon (1995), the Illinois River Bluffs area experiences two hail days per year, with the actual number varying greatly from year to year. The years with the most hail days were 1927, 1950, and 1954, each with seven. There are no indications of trends in hail days, based on these records.

Thunderstorms

On average, the Illinois River Bluffs area experiences about 40 days with thunderstorms each year. The annual number of days with thunder over the Illinois River Bluffs area since 1948 is shown in Figure 14, which is composed of data from Peoria (1948-1995). There is substantial year-to-year variation in thunderstorm days, ranging from as many as 56 in 1975 to as few as 23 in 1968. There is no significant trend in thunderstorm days.

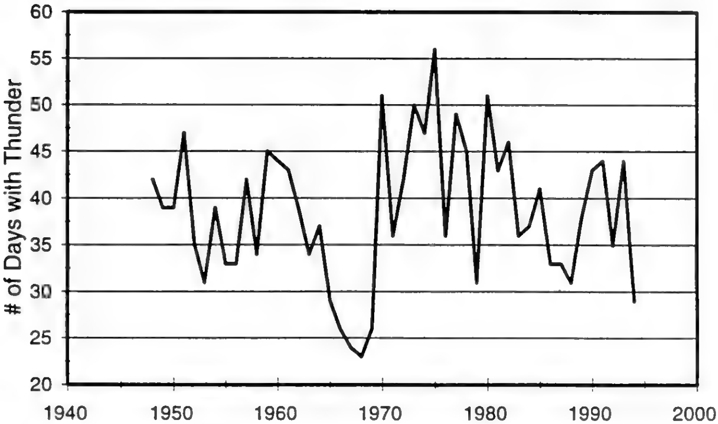


Figure 14. Annual Number of Days with Thunderstorms at Peoria, 1948-1995

Summary

Mean annual temperatures for Peoria show a warming trend through 1930, followed by a cooling trend until the early 1960s, before warming through 1996. The number of days with temperatures above or equal to 90°F shows an upward trend through 1938, followed by a slow decline through 1970, before returning to somewhat higher numbers from 1971 to 1996. The number of days with temperatures below or equal to 32°F shows no trends. The number of days with temperatures below or equal to 0°F shows no trends.

For precipitation, there are no trends. There were no trends in the number of days with measurable precipitation. For snowfall and the number of days with snow, there was an upward trend through the 1980s, followed by a downward trend through 1996.

Records extending back to 1901 show no clear trends in hail events. Similarly, there are no apparent trends in tornado events, although records date only to 1955. The number of days with thunderstorms has no significant trends since 1948.

Streamflow

Surface water resources are an essential component of any ecosystem because they provide different types of habitats for aquatic and terrestrial biota. In addition to their natural functions, they are sources of water supply for domestic, industrial, and agricultural uses. Changes in natural and human factors, such as climate, land and water use, and hydrologic modifications, can greatly affect the quantity, quality, and distribution (both in space and time) of surface waters in a river basin.

There are about 1,450 miles of rivers and streams in the Illinois River Bluffs area. Their streamflow is monitored by stream gaging stations, which measure the flow of water over time, providing information on the amount and distribution of surface water passing the station. Since it is not feasible to monitor all streams in a basin, gaging stations are established at select locations, and the data collected are transferred to other parts of the watershed by applying hydrologic principles. Streamflow records are used to evaluate the impacts of changes in climate, land use, and other factors on the water resources of a river basin.

The streams of the Illinois River Bluffs area consist of the Illinois River and a number of small- to medium-sized streams that drain the uplands and the bluffs. The variability of flows on the Illinois River is to a great degree influenced by large-scale rain events and climate influences from northeastern Illinois, which provides the major portion of the river's drainage area. Many of the tributary streams in the Illinois River Bluffs area are small, with flows rising and falling quickly in response to local climatic conditions. As a result, it is a fairly rare coincidence for the Illinois River and the local tributaries to be flooding at the same time or, in some cases, to be experiencing low flows at the same time.

Stream Gaging Records

Four stream gages in the Illinois River Bluffs area, presently or previously operated by the U.S. Geological Survey, have fifteen or more years of continuous daily flow data. These stations are listed in Table 8 and their locations are shown in Figure 15. Also listed in Table 8 is the Illinois River gage at Kingston Miles, located 22 miles downstream of the Illinois River Bluffs area, which provides a longer flow record for the Illinois River. The Gimlet Creek gaging station is located along the bluff line, while the Crow Creek (West) gage near Henry is located in the alluvial valley just below the bluff. The Crow Creek gage near Washburn is located in the flatter upland portion of that stream. Stream profiles (elevation versus distance upstream) for both Crow Creeks were given earlier (Figure 2).

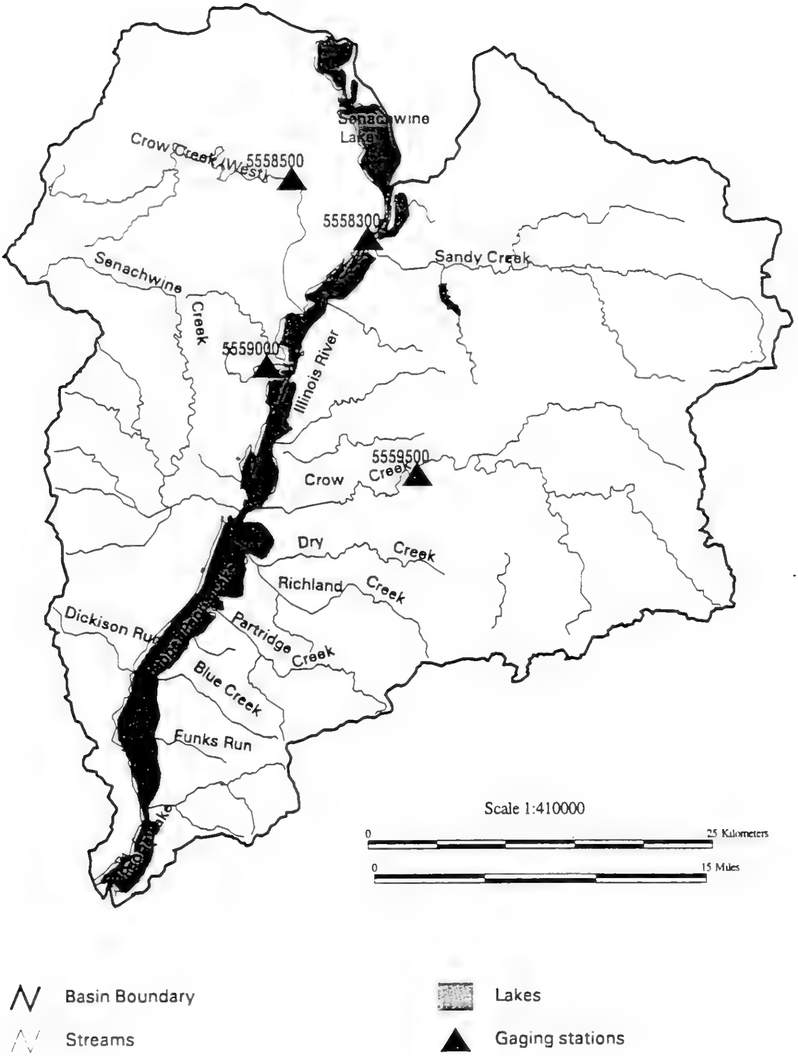


Figure 15. Stream Gaging Stations in the Illinois River Bluffs

Table 8. USGS Stream Gaging Stations with Continuous Discharge Records

USGS ID	Station name	Drainage Area (sq. mi.)	Record Length (years)	Period of record
05558300	Illinois River at Henry	13543.0	15	1981-present
05558500	Crow Creek (West) near Henry	56.2	22	1949-71
05559000	Gimlet Creek at Sparland	5.7	21	1950-71
05559500	Crow Creek near Washburn	115.0	27	1945-72
05568500	Illinois River at Kingston Mines[1]	15818.0	57	1939-present

Note: [1]Located 22 miles downstream of the Illinois River Bluffs area

Human Impacts on Streamflows in the Illinois River Bluffs Area

The characteristics of streamflow in any moderately developed watershed will vary over time because of the cumulative effect of human activities in the region. Like most locations in Illinois, the Illinois River Bluffs area has experienced considerable land use modification since European settlement, including cultivation, drainage modification, removal of wetland areas, and deforestation. Most modifications began prior to the onset of streamgaging activities, and thus their impact cannot usually be detected in the gaging records.

Climate variability has the greatest influence on streamflows from year to year and decade to decade. Its influence is usually large enough to help mask the impacts of the less obtrusive human modifications to flows, including that of land use modification. The major changes to streamflow during this century are assumed to occur from natural climatic variability, but it is possible that in the future they may be shown to have human influences.

Other modifications to the watershed, such as the construction of reservoirs, point withdrawals from, and discharges to the streams have readily definable impacts on the stream flows. The most noticeable impact of this type comes from the diversion of Lake Michigan water to the Illinois River, for use in public water supply to most of the Chicago metropolitan area and for maintaining water levels in the Chicago Ship and Sanitary Canal. This diverted water accounts for over 20 percent of the total annual flow in the river and over 70 percent of the flow during drought conditions.

Annual Streamflow Variability

Average streamflow varies greatly from year to year, and can also show sizable variation between decades. Figures 16a and 16b show the annual series of average streamflow for the Illinois River, and the tributaries in the Illinois River Bluffs area, respectively. For the Illinois River, the greatest and least annual runoffs occurred in 1993 and 1964, respectively. The long-term average flow for the Illinois River has been noticeably greater in the last 25 years since 1970. This can be attributed to coincident increases in annual precipitation and heavy rainfall events that have been observed in northeastern Illinois (Knapp, 1994; Kunkel, 1997).

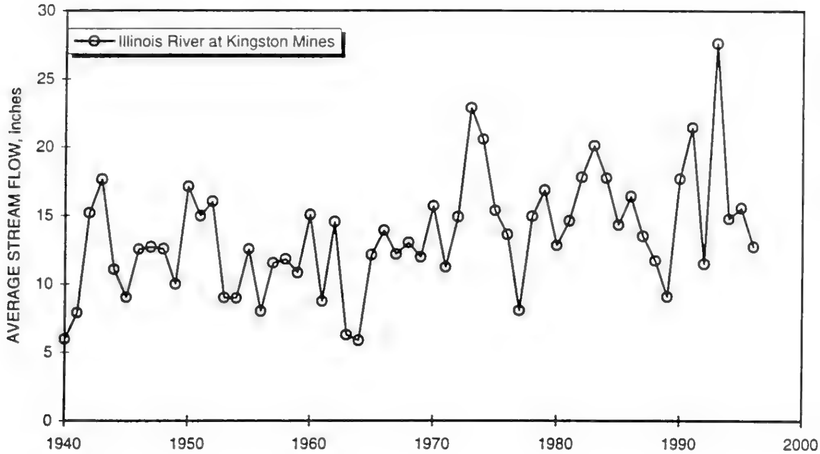
Streamgage records for the Illinois River at Henry indicate that the average annual flow for 1981-1996 has been 15,680 cubic feet per second (cfs); roughly 10% greater than the expected long-term average flow of 14,200 cfs. Of this flow amount, approximately 3,200 cfs originates from the Chicago diversion of Lake Michigan water into the Illinois River waterway. The remaining amount of flow is runoff from all portions of the watershed, and on average represents an equivalent runoff of 11 inches per year.

The average flow for the tributaries in the Illinois River Bluffs area do not appear to have any trends. The average runoff of these tributaries over their periods of record ranges from 7 to 9 inches per years, and the long-term average runoff from these streams is expected to be about 9 inches. The greatest total annual flow on the tributaries occurred in 1970, with an annual runoff of over 20 inches. The least annual runoff, less than inch, was experienced in 1956.

Statistical Trend Analysis

Table 9 shows trend coefficients estimated for the annual flow record for individual stations. The trend analysis identifies a statistically significant increase in average flow for the Illinois River at Kingston Mines since 1939. On the other hand, the Illinois River at Henry (1981-1996) shows a significant decreasing trend over the last 15 years. This emphasizes the fact that trends in streamflow are dynamic and can vary significantly depending on the period of years being analyzed.

Of additional interest is the season during which the flow increases have occurred. The trend statistics indicate that the average streamflows during the fall season have increased for all stations. The change in streamflows during other seasons are variable depending on location and period of record.



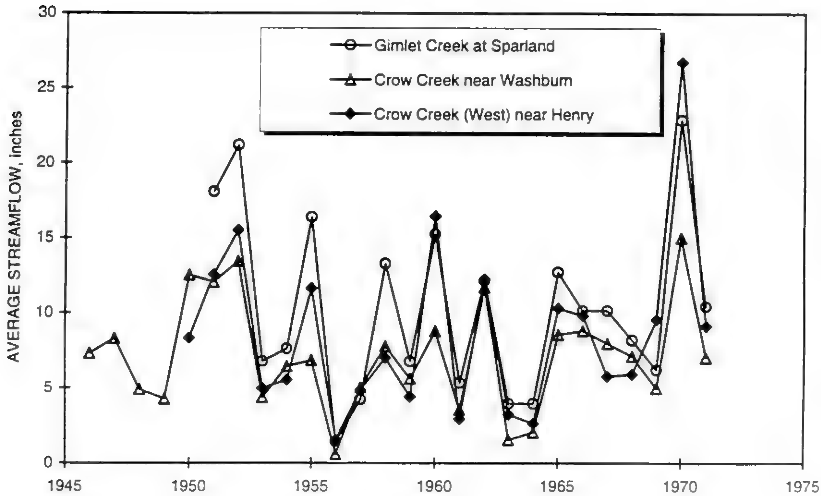


Figure 16. Average Annual Streamflow for a) the Illinois River, and b) the Tributaries in the Illinois River Bluffs Area

Table 9. Trend Correlations for Annual and Seasonal Flows

Station and Period of Record	Annual	Kendall trend correlation Fall	Winter	Spring	Summer
Crow Creek (West) near Henry (1949-71)	0.013	0.169	0.022	-0.100	-0.108
Gimlet Creek at Sparland (1950-71)	-0.057	0.133	0.048	-0.076	-0.152
Crow Creek near Washburn (1946-72)	-0.060	0.066	-0.128	0.128	-0.202
Illinois River at Henry (1981-95)	-0.303	0.121	-0.030	-0.303	0.212
Illinois River at Kingston Mines (1940-95)	0.244	0.343	0.216	0.110	0.079

Daily and Seasonal Flow Variability

Figure 17 plots the flow duration curves for the gages in the Illinois River Bluffs area. The flow duration curve provides an estimate of the frequency with which the given flows are exceeded. The shapes of the flow duration curves shown in Figure 17 display the differences that would be expected between small and large watersheds. The flows for the smaller tributaries tend to be highly variable; the peak flow rates measured at these gages are typically five to ten times greater than the maximum flow rate averaged over a one-day period, indicating a "flashy" nature with a quick rise and fall. Smaller streams will also typically dry up during the late summer and fall. As shown in Figure 17, Gimlet Creek is dry over one-third of the time. Larger streams will go dry during drought periods, perhaps only 10 percent of the time, as shown for Crow Creek near Washburn. The gage for Crow Creek (West) near Henry is located in an alluvial valley and shows a more sustained amount of low flow.

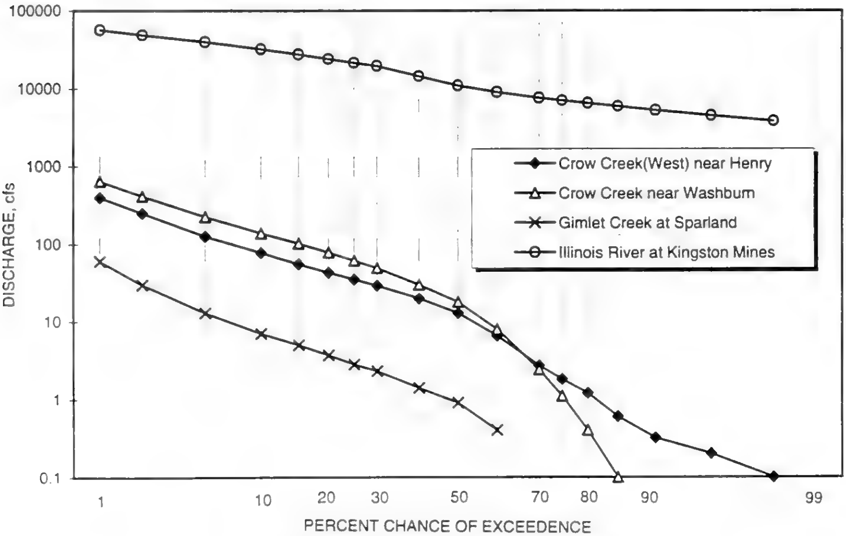


Figure 17. Flow Duration Curves (Discharge Versus Probability)

Flows on the Illinois River are much more gradual, influenced by the great amount of water storage in its large watershed. The typical range of flows on the Illinois River is from 4,000 to 50,000 cfs, with a historical minimum and maximum of 2,100 and 108,000 cfs, respectively.

As with all other locations in Illinois, streams in the Illinois River Bluffs area display a well-defined seasonal cycle. Figure 18 shows the probability of flow rates on Crow Creek near Washburn for each month of the year. As shown, flows tend to be greatest during the spring and early summer months, March through June, dropping to their minimum values by late summer and autumn.

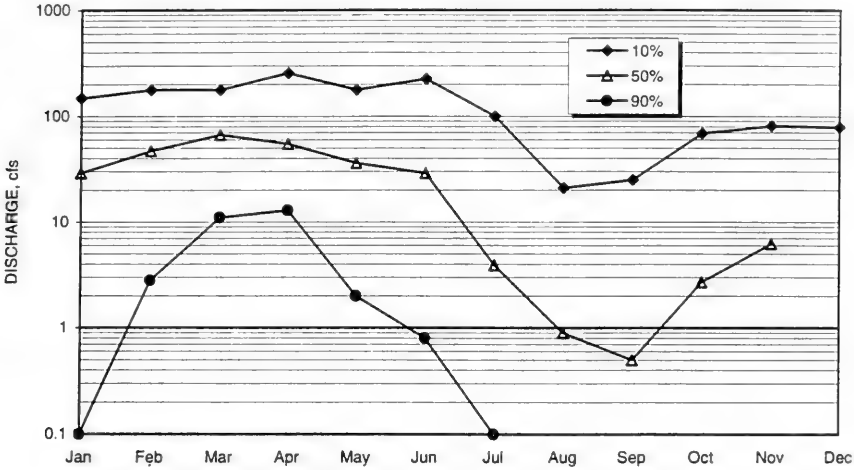


Figure 18. Monthly Flow Probabilities for Crow Creek near Washburn

Flooding and High Flows

Ramamurthy et al. (1989) and Singh and Ramamurthy (1990) examined the increases in peak flows observed on the Illinois River for the period 1941-1985. These studies found that the annual peak flows showed a significant increase of about 50% over this period, and that the higher flows were caused by concurrent increases in precipitation amounts in the river's watershed. Northeastern Illinois, in particular, has experienced a significant increase in the magnitude and frequency of heavy precipitation events (Kunkel et al., 1997). The following data provide an update of these previous trend studies, using data up through 1996, as well as information on flooding trends for tributaries in the Illinois River Bluffs area.

Figure 19a shows the annual series of peak flood discharges for the Illinois River at Kingston Mines and Henry. The two highest floods on record for the Illinois River at Kingston Mines occurred in 1982 and 1943. As indicated by the Kingston Mines series, there has been an gradual increase in flooding over the last 55 years; however, over the last 15 years there has been a downward trend in peak flood values, as seen in both the Henry and Kingston Mines records. There is no detectable trend in flooding at any of the tributary stations, as illustrated in Figure 19b.

Statistical Trend Analysis

Results of a statistical trend analysis of flood records are given in Table 10. The results show that the detection of flood trends is greatly impacted by the period of record being analyzed, with higher coefficients observed when the gaging record either starts during a drought period or ends with a major flood. Two general conclusions may be drawn from these coefficients: 1) there is an general increase in flooding for the Illinois River from 1940 to the present, but there is also a downward trend since 1981; and 2) the smaller tributaries in the Illinois River Bluffs area have generally not experienced significant flood trends over their period of gaging, although the flood peaks for Crow Creek near Washburn show a reduction in flooding for the period 1946-1979.

Table 10. Trend Correlations for Flood Volume and Peak Flow

		Kendall trend correlation	
Station name	Period of record	7-day high flow	Peak flow
Crow Creek near Henry	1950-1971	0.117	-----
	1950-1976	-----	0.014
Gimlet Creek at Sparland	1951-1971	-0.133	-----
	1950-1982	-----	-0.055
Crow Creek near Washburn	1946-1972	-0.117	-----
	1946-1979	-----	-0.202
Illinois River at Kingston Mines	1940-1996	0.157	0.129
	1981-1996	-0.385	-0.317
Illinois River at Henry	1981-1996	-0.455	-0.250

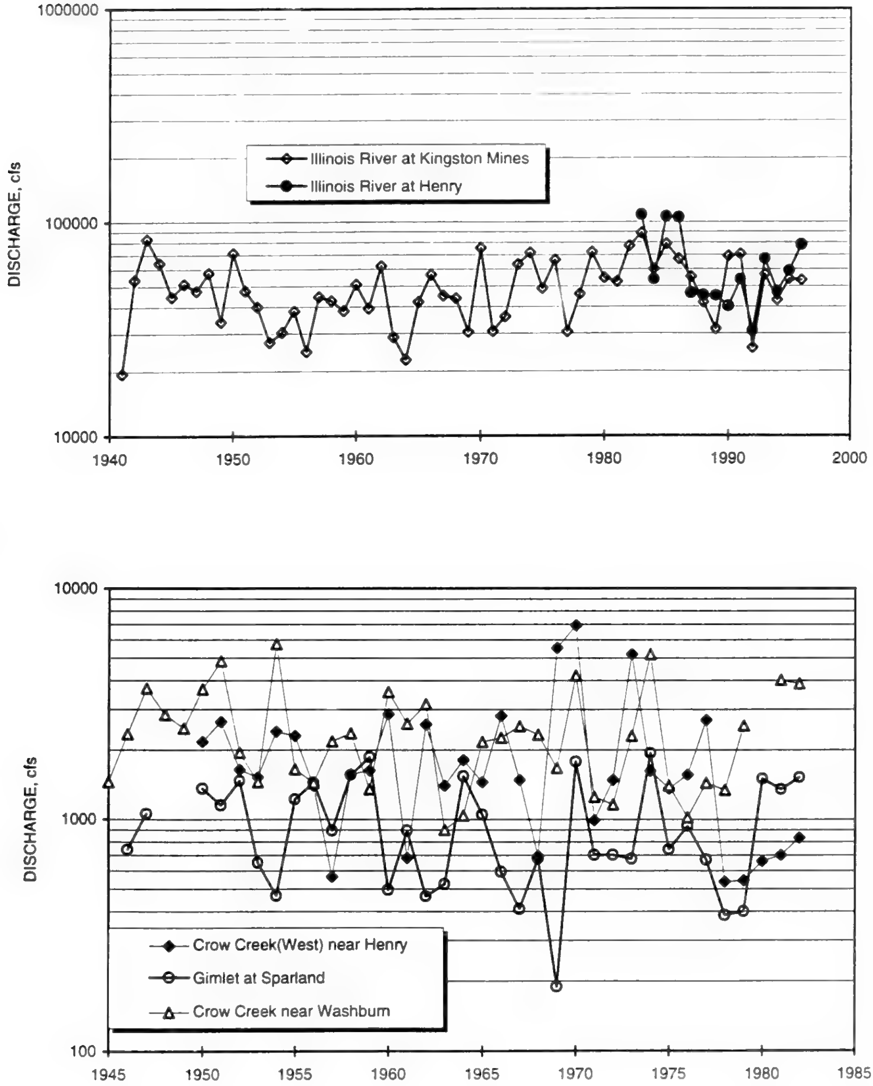


Figure 19. Annual Peak Discharges for a) the Illinois River, and b) the Tributaries in the Illinois River Bluffs Area

Impact of Peoria Lake on Peak Flows

An examination of Figure 19a also shows that, for all major flood events, the peak discharge on the Illinois River is significantly greater at Henry than at Kingston Mines. This occurs despite the fact that the drainage area at Kingston Mines is 20 percent greater than that at Henry, which causes the Kingston Mines location to have a significantly greater volume of flood waters. As illustrated in Figure 20, the peak discharges on the Illinois River are greatly reduced when flood waters pass through Peoria Lake. The lake, and other bottomland areas along the Illinois River, temporarily store much of the flow volume of these major flood events. Flood water is naturally released from Peoria Lake at a much more gradual rate, causing lower flood peaks. The outflow from Peoria Lake, as observed at Kingston Mines, may not surpass the inflow (at Henry) for well over a week after the peak flood flow has passed. Operation of the Peoria Lock and Dam has minimal impact on the flood storage provided by Peoria Lake and the adjacent bottomlands.

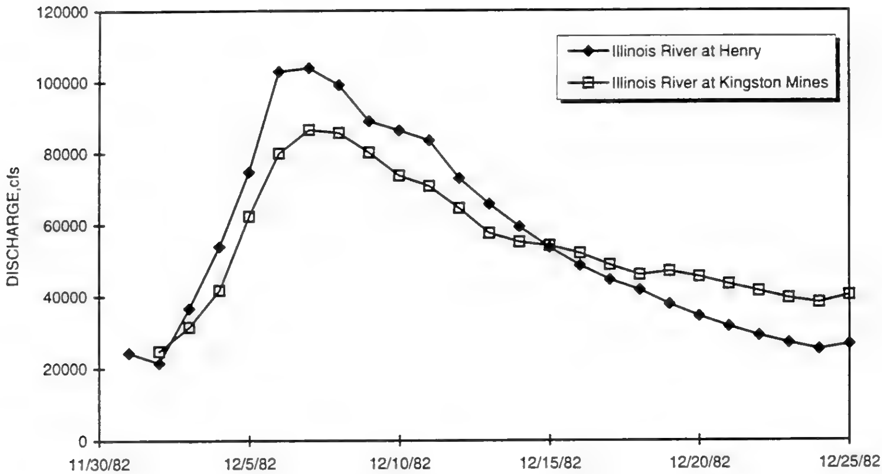


Figure 20. December 1982 Flood Hydrographs for the Illinois River at Henry and Kingston Mines

Seasonal Distribution of Flood Events

Table 11 presents the monthly distribution of the top 25 flood events for four gaging stations. For the Illinois River, major flooding occurs predominantly during spring, March through May. For the tributaries, a combination of locally-heavy rainfall and wet soil moisture conditions causes late spring and early summer flooding.

Table 11. Monthly Distribution of Top 25 Flood Events

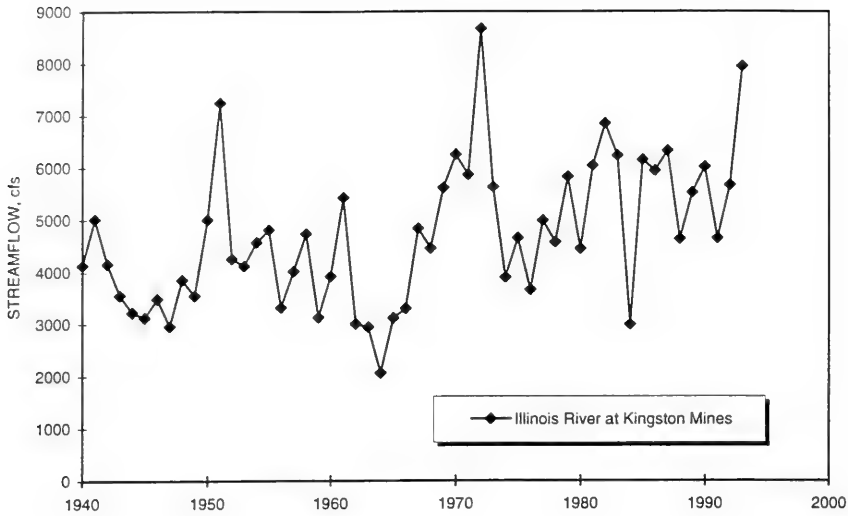
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crow Creek (West) near Henry	0	2	2	4	3	8	3	1	2	0	0	0
Gimlet Creek at Sparland	0	0	1	3	3	8	5	1	1	0	0	0
Crow Creek near Washburn	1	2	5	4	2	6	1	1	3	0	0	0
Illinois River at Kingston Mines	2	2	7	4	5	1	0	0	0	1	1	2

Drought and Low Flows

The 7-day low flow (Q7) is used herein to describe the minimum streamflows expected during a drought or dry period. The Q7 is defined as the minimum average flow experienced during a seven-day period in that year. This minimum flow is useful for evaluating the effect of dry periods on river navigation. The 7-day, 10-year low flow is the lowest Q7 that would be expected to occur on average only once in ten years, and is commonly used for defining the minimum amount of dilution for streams receiving treatment effluents.

Figure 21 presents the 7-day low flows computed for the Illinois River at Kingston Mines and the three tributary streams in the Illinois River Bluffs area. For the Illinois River, there is a significant increase in its low flows beginning in the late 1960s. This increase is generally proportional to and coincides with the increase in average streamflows, presented earlier. Low flows on the Illinois River are considerably greater than they were prior to 1900, resulting from the diversion of Lake Michigan water to the Illinois River basin.

Many of the smaller tributaries in the Illinois River Bluffs area have zero flows during most summers or any extended dry period. Some of the largest tributaries have at least a small amount of flow throughout the entire year except during major droughts. The low flow records for the tributary streams in the Illinois River Bluffs area do not show any trends.



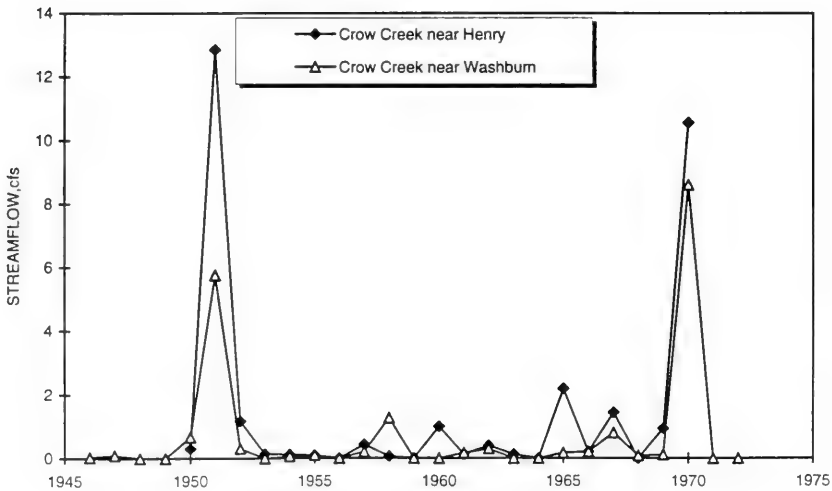


Figure 21. Annual 7-Day Low Flows for a) the Illinois River, and b) the Tributaries in the Illinois River Bluffs Area

Summary

Since 1970 there has been a significant jump in the average annual flow in the Illinois River Bluffs area, a trend in many Illinois rivers. This increase in streamflow directly corresponds to a concurrent increase in average annual precipitation. There have been no observed trends in streamflows since the early 1970s, nor were there any observed trends in flow for the earlier period of record prior to 1970.

There has also been a general increase in high flows and low flows related to the considerable jump in average streamflow amounts. However, the trend analysis indicates no overall increase in peak discharges.

Erosion and Sedimentation

Instream Sediment Load

Instream sediment load is the component of soil eroded in the watershed and from the streambanks that is transported to and measured at a gaging station. It indicates the actual amount of soil generated upstream of the gaging station and eventually transported to downstream reaches of the river. Given the complex dynamic process of soil erosion, sediment transport, and deposition, it is difficult to quantify how much of the soil eroded from uplands and streambanks actually moves to downstream reaches.

The sediment transported by a stream is a relatively small percentage of the total erosion in the watershed. However, the amount of sediment transported by a stream is the most reliable measure of the cumulative results of soil erosion, bank erosion, and sedimentation in the watershed upstream of a monitoring station.

There is only one gaging stations in the Illinois River Bluffs area where instream sediment has been monitored for some time. As shown in Figure 22, this station is located on the Illinois River at Chillicothe. Table 12 summarizes information about the monitoring station.

Table 12. Sediment Monitoring Stations in the Illinois River Bluffs Area

Station name	USGS station number	Drainage area (sq. mi.)	Period of record
Illinois River at Chillicothe	05559600	Not determined	May. 1993–Sept. 1996

At the Illinois River near Chillicothe, the U.S. Geological Survey (USGS) monitored sediment yield for four water years (1993-1996). Data collected by the USGS were reported as daily average concentrations. Therefore, daily and annual sediment loads at the station can be calculated.

Data were collected by the Illinois State Water Survey (ISWS) for two water years (1989-1990) at ten small tributaries within the Illinois River Bluffs area, including Crow Creek, Dry Creek, Richland Creek, Partridge Creek, Blue Creek, Funk's Run, Tenmile Creek, Senachwine Creek, Dickison Run, and Farm Creek. These tributaries are shown in Figure 22, and their respective drainage areas are given in Table 13. The sediment data collected by the ISWS were instantaneous weekly samples. Therefore, only instantaneous sediment loads can be calculated, not average daily or annual sediment loads.

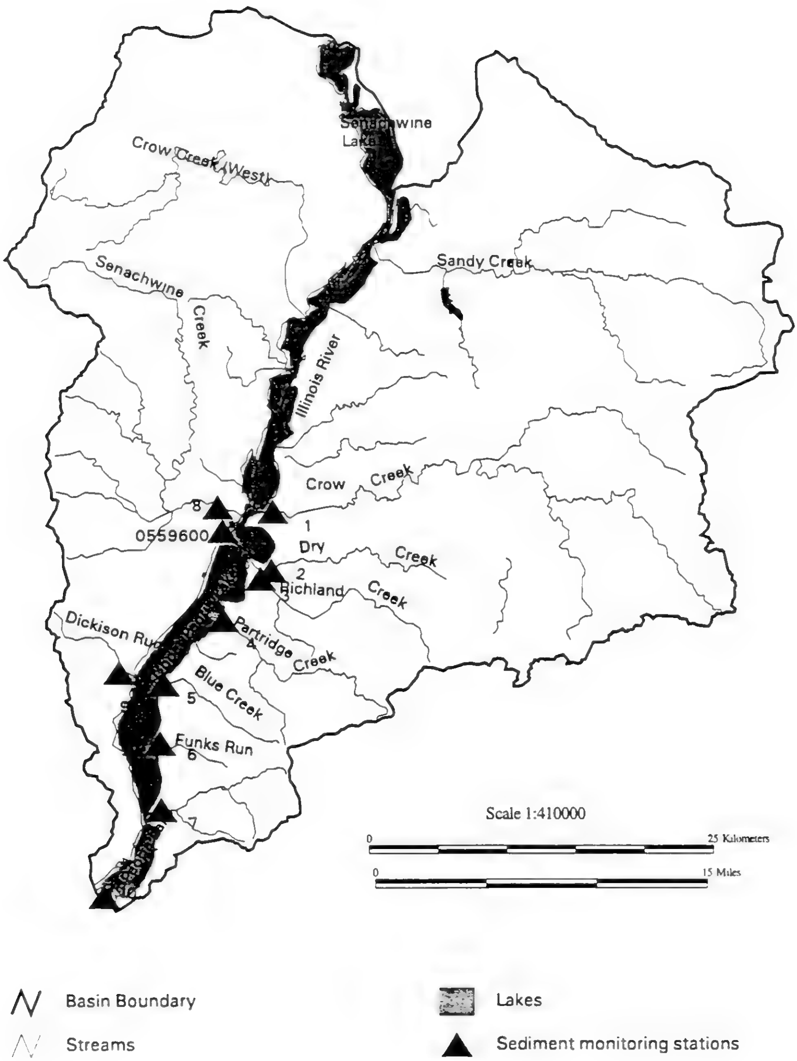


Figure 22. Sediment Monitoring Stations in the Illinois River Bluffs

Table 13. Tributary Streams in the Illinois River Bluffs Area

Site number	Name of stream	Drainage area (sq. mi.)
1	Crow Creek	130.0
2 and 3	Dry and Richland Creek	47.0
4	Partridge Creek	28.0
5	Blue Creek	10.5
6	Funk's Run	5.4
7	Tenmile Creek	17.6
8	Senachwine Creek	85.0
9	Dickison Run	7.9
10	Farm Creek	60.0

Figures 23-33 show the variabilities of daily and instantaneous streamflows (Q_w), suspended sediment concentrations (C_s), and suspended sediment loads (Q_s) for all monitoring stations and tributaries. For the Illinois River at Chillicothe (Figure 23), concentrations varied from a low of 17.7 milligram per liter (mg/l) to a high of 491.4 mg/l. Higher concentrations generally occurred in May or June for the four water years observed.

For Crow Creek (Figure 24), concentrations varied from a low of 1 mg/l to a high of 4,940 mg/l over the two-year period, with higher concentrations occurring during June and July. For Dry Creek (Figure 25), concentrations varied from a low of 6 mg/l to a high of 13,700 mg/l. There is no significant trend in sediment concentrations for the monitoring period. For Richland Creek (Figure 26), concentrations varied from a low of 2 mg/l to a high of 8,210 mg/l over the two-year period, with higher concentrations occurring during May and June. For Partridge Creek (Figure 27), concentrations varied from a low of 1 mg/l to a high of 11,430 mg/l. Higher concentrations occurring during September for water year 1989 and July for water year 1990. For Blue Creek (Figure 28), concentrations varied from a low of 4 mg/l to a high of 22,700 mg/l. There is no significant trend in sediment concentrations for the two-year monitoring period. For Funk's Run (Figure 29), concentrations varied from a low of 3 mg/l to a high of 7,120 mg/l. There is no significant trend in sediment concentrations for the two-year period. For Tenmile Creek (Figure 30), concentrations varied from a low of 1 mg/l to a high of 5,690 mg/l over the two-year period. Higher concentrations occur during May for water year 1989 and during July for water year 1990. For Senachwine Creek (Figure 31), concentrations varied from a low of 2 mg/l to a high of 7,030 mg/l over the two-year period, with higher concentrations occurring during June or July. For Dickison Creek (Figure 32), concentrations varied from a low of 6 mg/l to a high of 6,950 mg/l. There is no significant trend in sediment concentrations for the monitoring period. For Farm Creek (Figure 33), concentrations varied from a low of 1 mg/l to a high of 2,870 mg/l. Higher concentrations occurred during May for water year 1989 and during June for water year 1990.

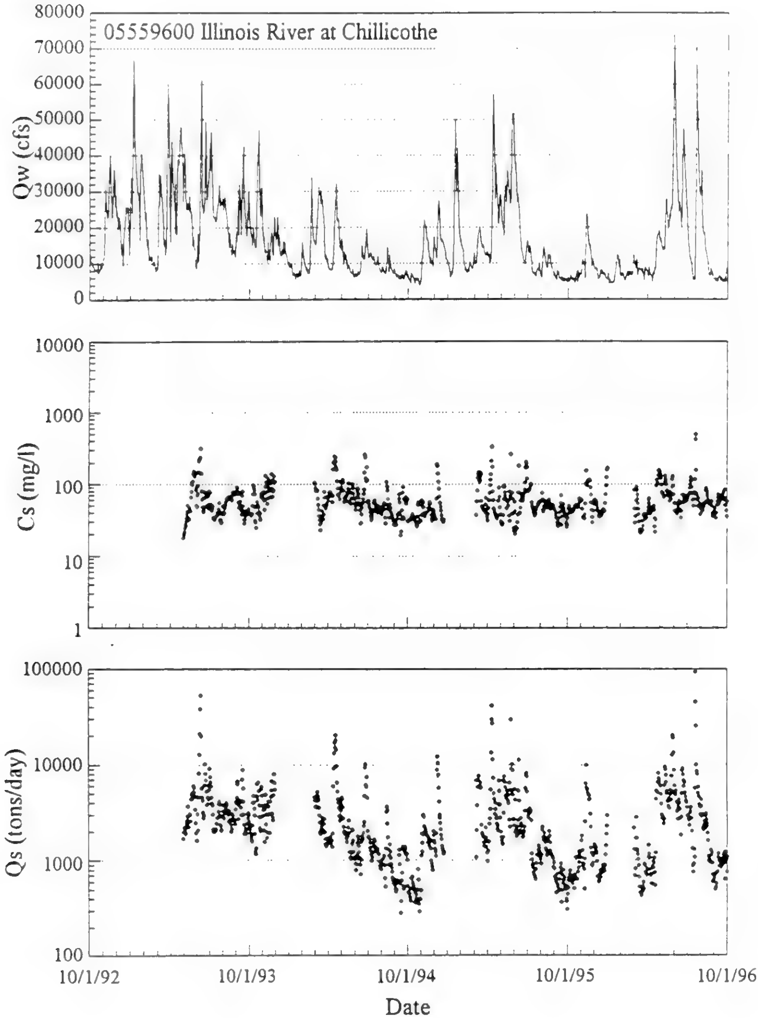


Figure 23. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for the Illinois River at Chillicothe

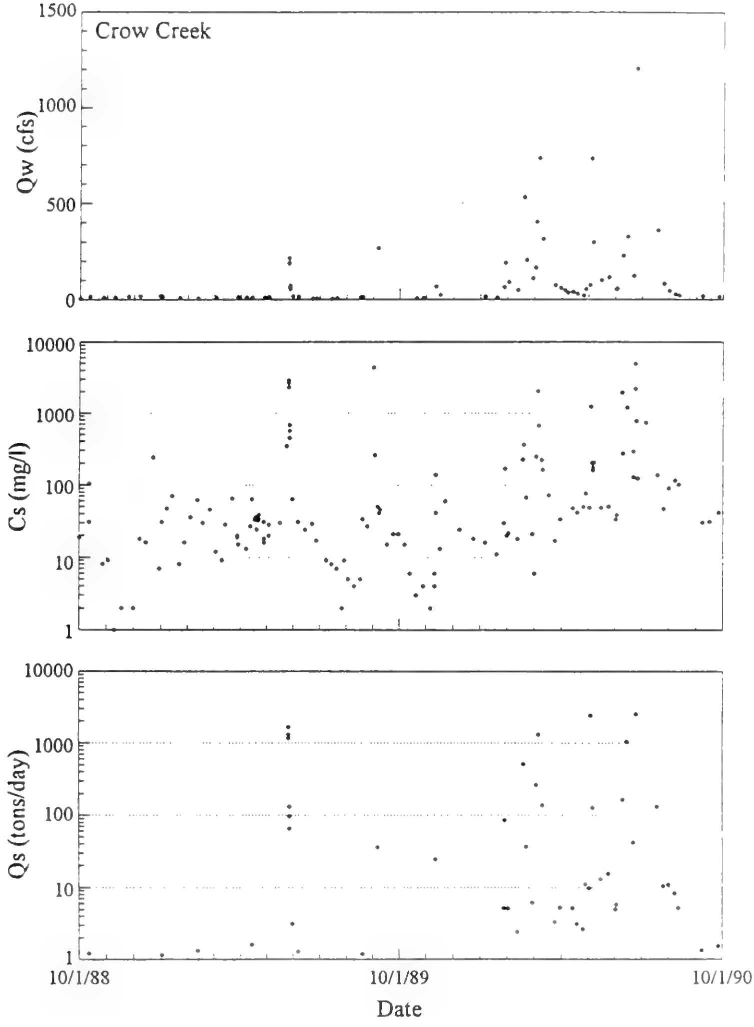


Figure 24. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Crow Creek

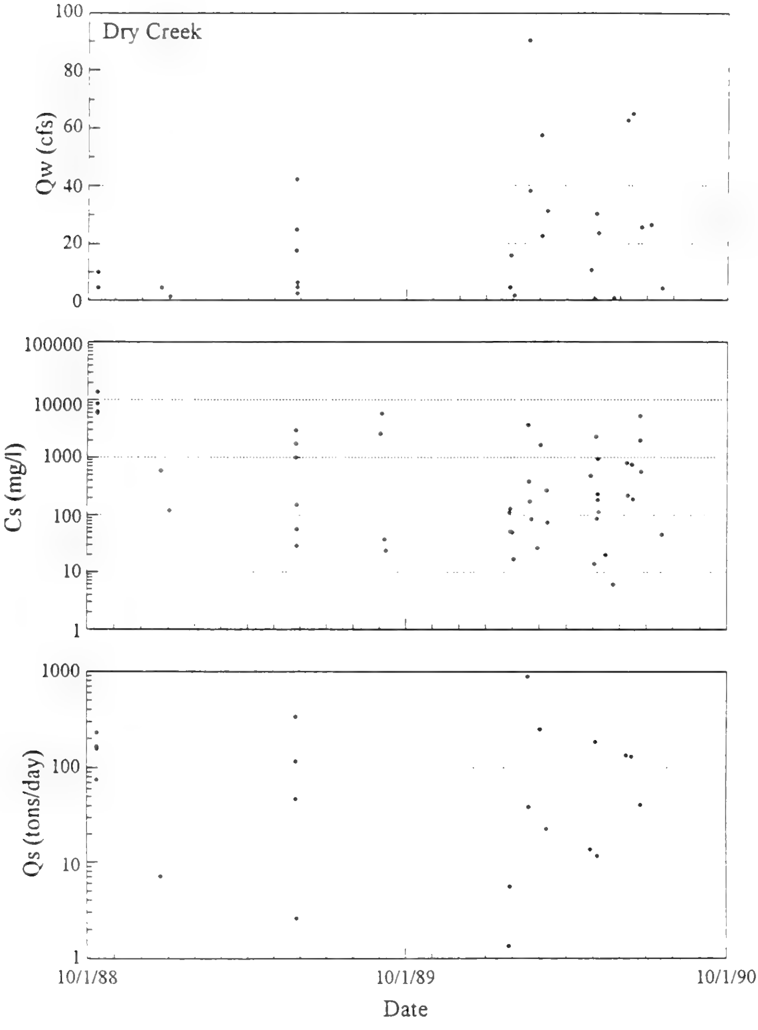


Figure 25. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Dry Creek

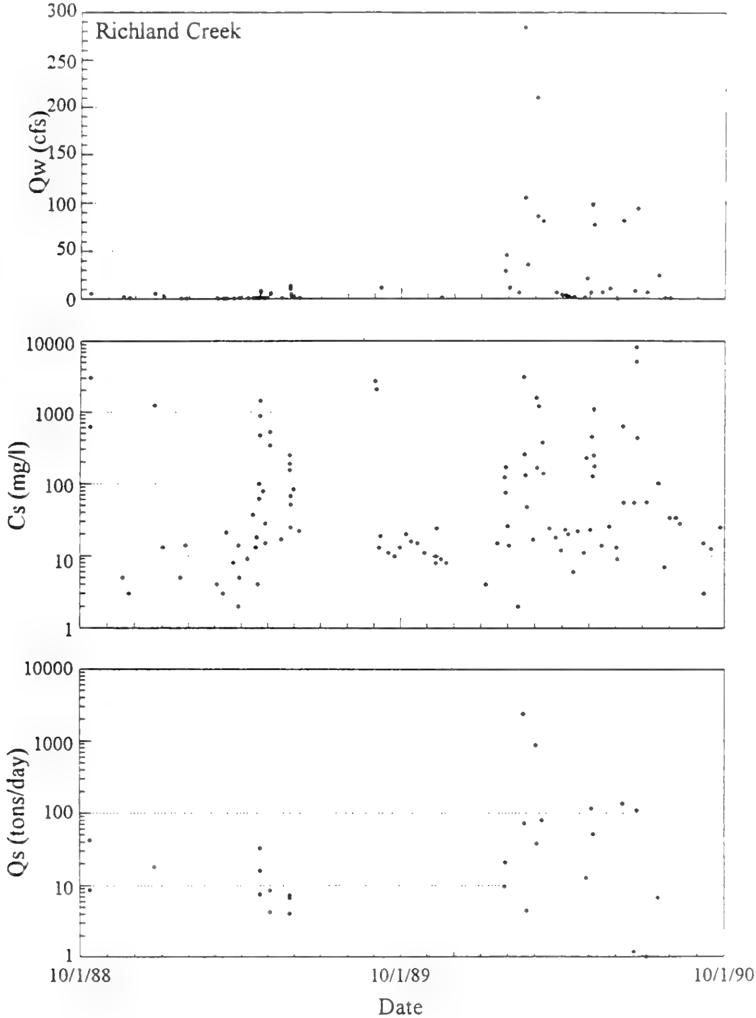


Figure 26. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Richland Creek

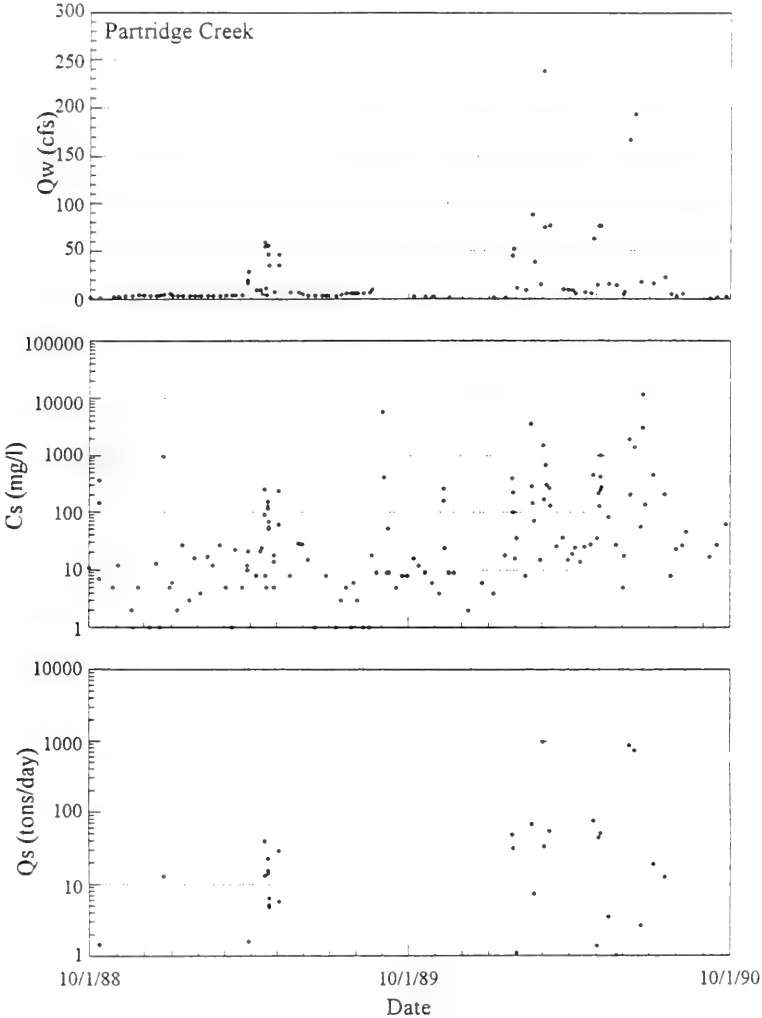


Figure 27. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Partridge Creek

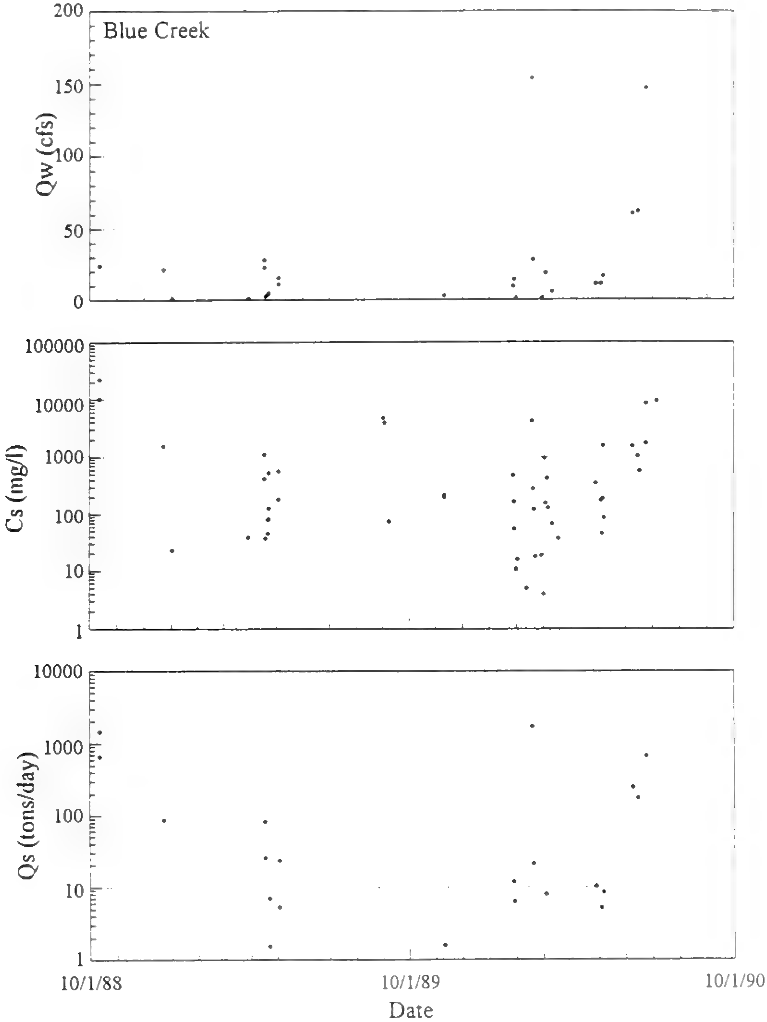


Figure 28. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Blue Creek

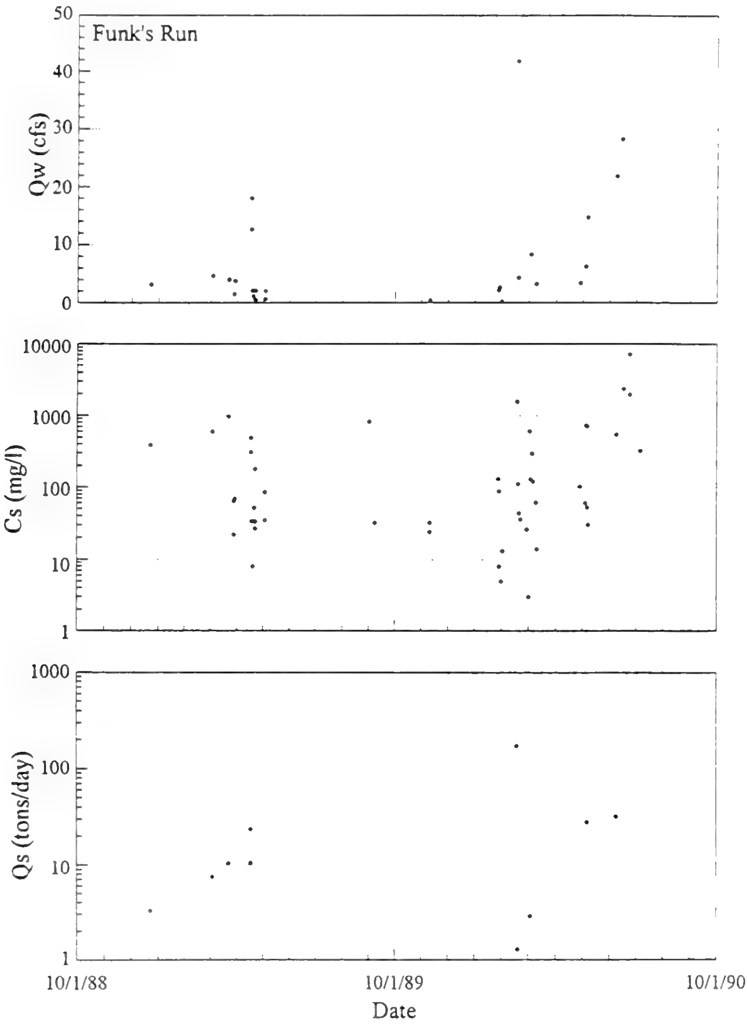


Figure 29. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Funk's Run

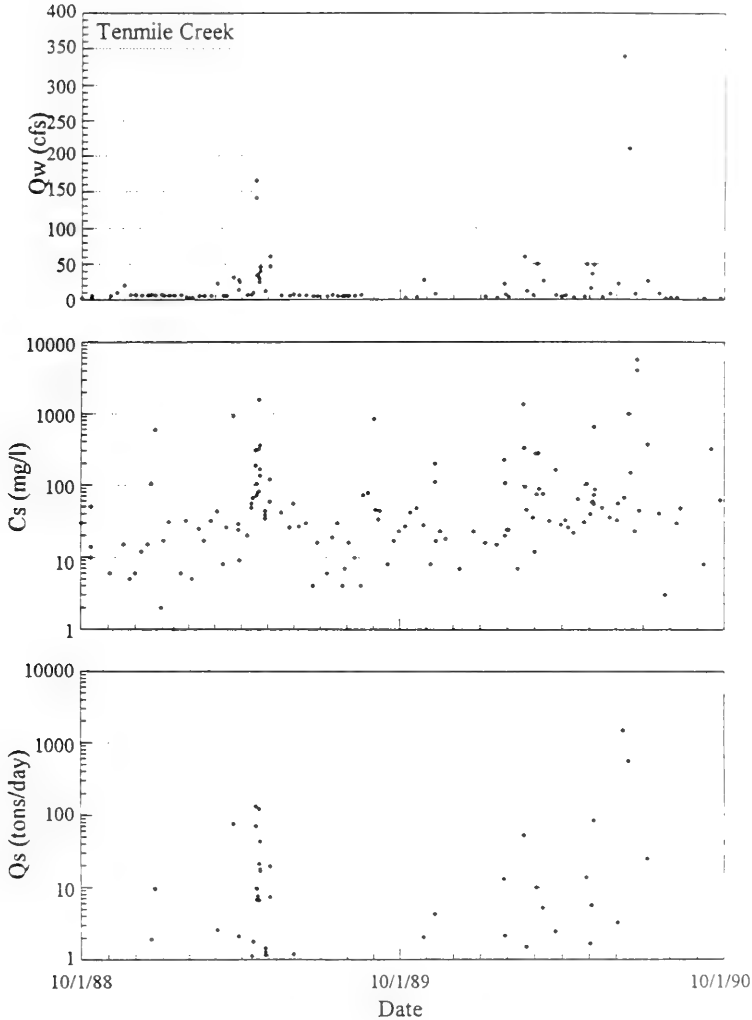


Figure 30. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Tenmile Creek

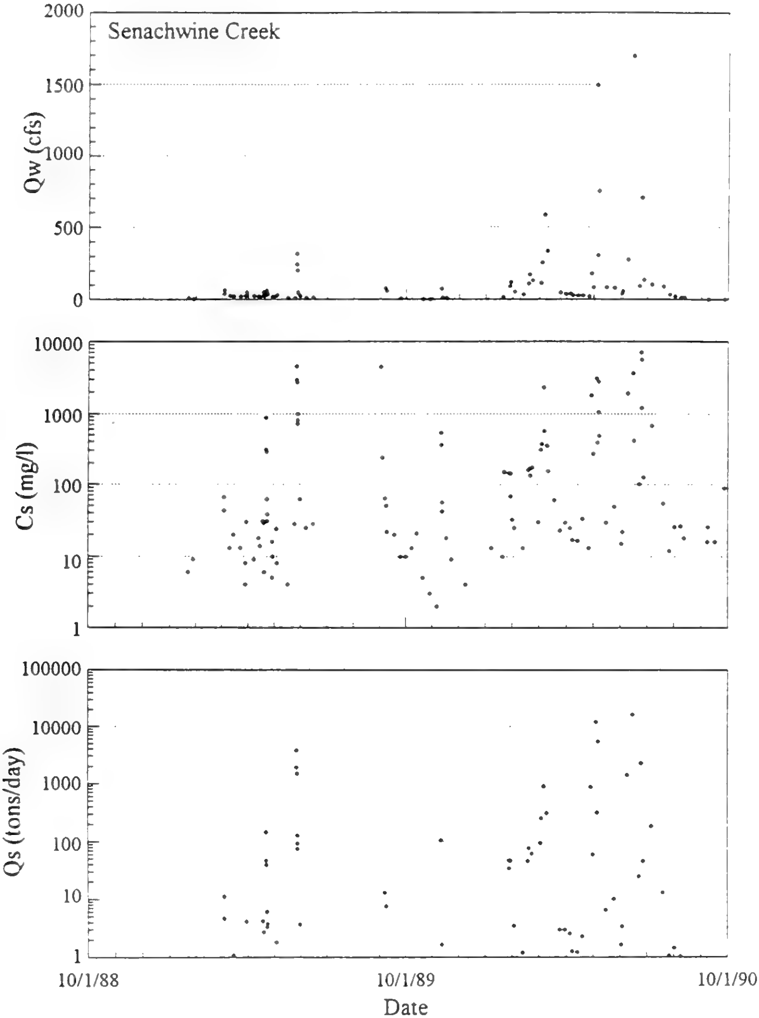


Figure 31. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Senachwine Creek

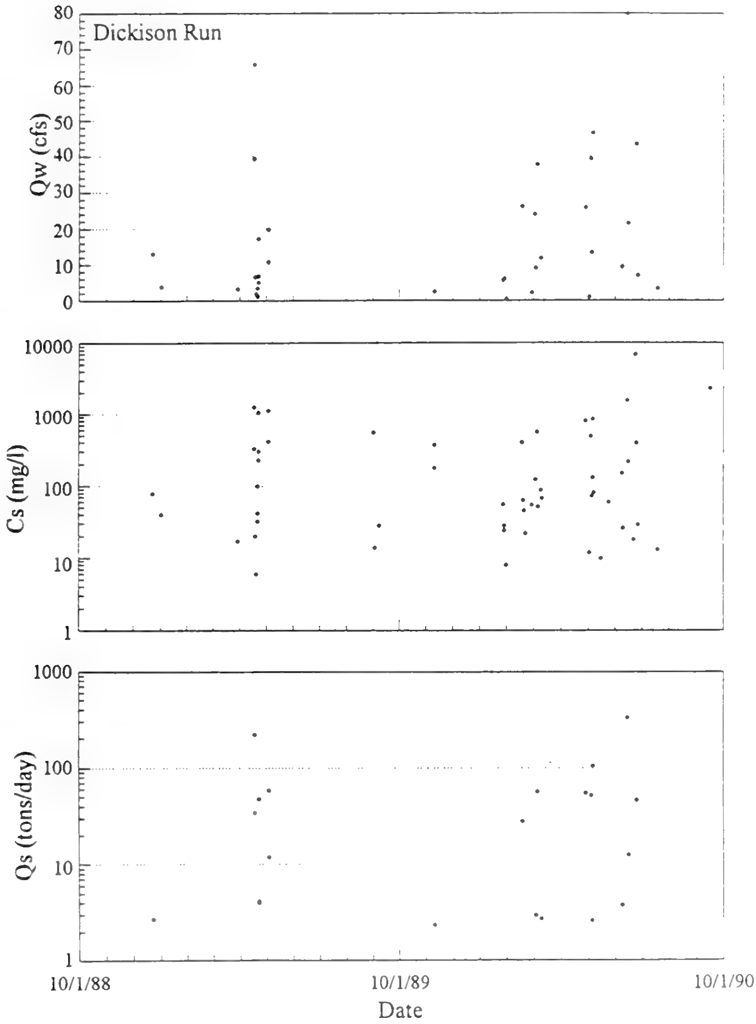


Figure 32. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Dickison Run

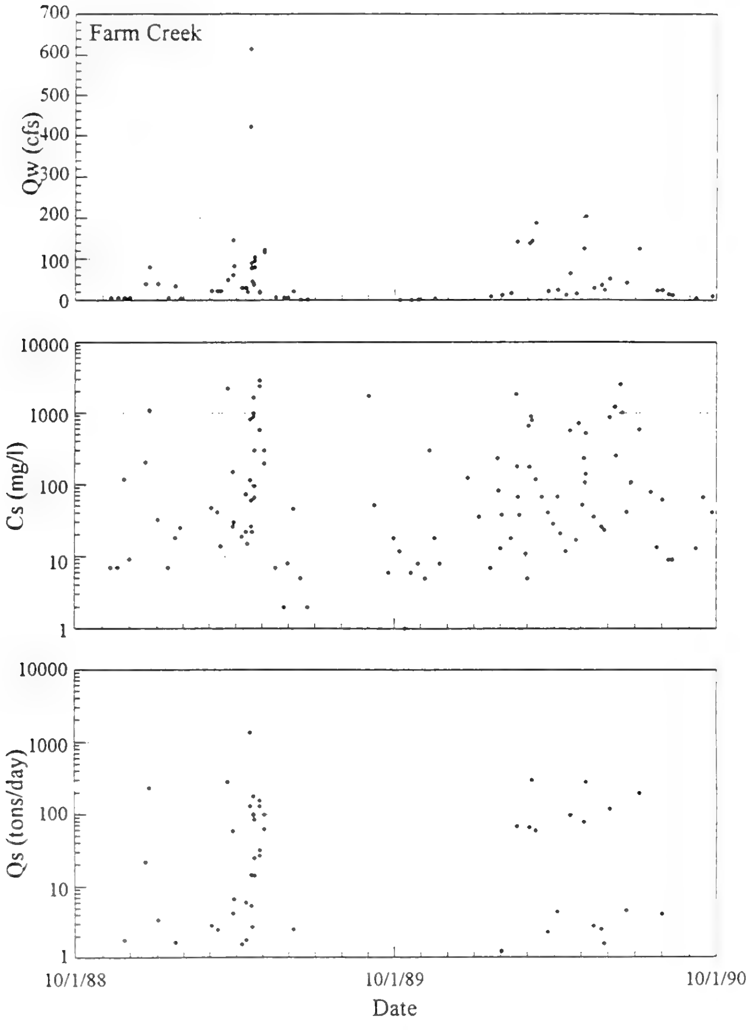


Figure 33. Variabilities of Flow Discharge and Instantaneous Suspended Sediment Concentration and Load for Farm Creek

To provide values in tons per day, sediment load was computed by multiplying the daily water discharge by the instantaneous sediment concentrations and applying the proper unit conversion factors. For stations with weekly sediment sampling, it was not possible to compute average daily and annual sediment loads. However, instantaneous sediment load provides a range of values to compare variability of sediment from year to year and from station to station.

For the Illinois River at Chillicothe, the sediment load varied from 284 tons per day to 93,800 tons per day for the four water years monitored. It should be noted that sediment load depends on the size of the drainage area; therefore, a station with a larger drainage area will generally have a higher sediment load than one with a smaller drainage area under similar conditions.

No annual sediment load can be calculated for the Illinois River at Chillicothe. This is because sediment load for each water year at this station was only for a period of five, nine, or ten months (see Table 14).

Table 14. Annual Sediment Load for the Illinois River at Chillicothe

Water year	Water discharge (cfs)	Sediment load (tons)
1993	8,933,370	677,950 [1]
1994	4,836,430	730,182 [2]
1995	5,631,210	824,982 [3]
1996	4,909,800	943,638 [3]

Note: [1] Represents a five-month total, [2] represents a nine-month total, and [3] represents a ten-month total.

Sedimentation

Sedimentation is the process by which eroded soil is deposited in stream channels, lakes, wetlands, and floodplains. In natural systems that have achieved dynamic equilibrium, the rates of erosion and sedimentation are in balance over a long period of time. This results in a stable system, at least until disruption by extreme events. However, in ecosystems where there are significant human activities, such as farming, construction, and hydraulic modifications, the dynamic equilibrium is disturbed, resulting in increased rates of erosion in some areas and a corresponding increased rate of sedimentation in other areas.

Erosion rates are measured by estimating soil loss in upland areas and measuring streambank and bed erosion along drainageways. These measurements are generally not very accurate and thus are estimated indirectly, most often through evaluation of sediment transport rates based on instream sediment measurements and empirical equations. Similarly, measurement of sedimentation rates in stream channels is very difficult and expensive.

Lake sedimentation surveys provide the most reliable sedimentation measurements. Since lakes are typically created by constructing dams across rivers, creating a stagnant or slow-moving body of water, they trap most of the sediment that flows into them. The continuous accumulation of eroded soils in lake beds provides a good measure of how much soil has been eroded in the watershed upstream of the lake.

In the Illinois River Bluffs area, surveys have been conducted for 3 lakes (Table 15). The sedimentation rates (in percent per year) for these lakes are high in comparison to most Illinois lakes, primarily because they involve extensive watershed areas draining into relatively small lakes.

There are no sedimentation surveys for constructed reservoirs in the Illinois River Bluffs area. Records for the water depth of Peoria Lake have been collected and analyzed for sedimentation rates for the years 1903, 1965, 1976, and 1985. The sedimentation analyses for these surveys were analyzed by Demissie and Bhowmik (1986). An additional survey by the Corps of Engineers in 1988 is not used in this analysis due to the limited record length between the 1985 Water Survey study and the 1988 survey.

These analyses are presented in the Table 15. Comparison of the pre-1965 to the post-1965 rates and volumes should be made with caution. The rate for the period 1903 to 1965 includes the influence of several significant alterations to the watershed and river systems. These include 1) the early flows of the Illinois waterway from the Sanitary and Ship Canal and the manipulation of these flows to meet court-ordered withdrawal rates from Lake Michigan, 2) the construction of the Peoria Lock and Dam structures, 3) development of agricultural levee and drainage systems in the Illinois River Valley, and 4) agricultural drainage systems in the Peoria Lake area that bypassed the shoreline wetlands around the Lake.

Table 15. Lake Sedimentation Rates in the Illinois River Bluffs Area
(Volumes in acre-feet)

Lake name	Year surveyed	Volume acre-feet	Average depth feet	Average depth loss feet per year
Upper Peoria Lake	1903	96,000	7.6	
	1965	55,200	4.4	0.05
	1976	42,200	3.4	0.09
	1985	11,800	5.3	0.07
Lower Peoria Lake	1903	24,000	9.8	
	1965	17,700	7.2	0.04
	1976	14,400	5.9	0.12
	1985	11,800	5.3	0.07
Peoria Lake	1903	120,000	8.0	
	1965	72,900	4.8	0.05
	1976	56,600	3.8	0.09
	1985	38,300	2.6	0.13

Water Use and Availability

Statewide, water use has increased a modest 27% since 1965 (Illinois Department of Energy and Natural Resources, 1994). Most of that increase is in power generation. Water use for PWS has risen only about 7% during that time, less than the concurrent percentage increase in population. The number of public ground-water supply facilities in Illinois has risen significantly during that time, yet the total amount supplied by ground water remains near 25%.

A dependable, adequate source of water is essential to meeting existing and potential population demands and industrial uses in Illinois. Modifications to and practical management of both surface and ground-water use have helped make Illinois' water resources reliable. As individual facilities experience increases in water use, innovative alternative approaches to developing adequate water supplies must be developed, such as use of both surface and ground waters. Major metropolitan centers such as the Chicago area, Peoria, and Decatur, as well as smaller communities, have already developed surface and ground-water sources to meet their development needs and to sustain growth. The construction of impounding reservoirs has become and will remain economically and environmentally expensive, making it a less common approach.

Proper management of water resources is necessary to ensure a reliable, high quality supply for the population. Water conservation practices will become increasingly important to reduce demand and to avoid exceeding available supplies. Both our ground-water resources and surface reservoir storage must be preserved to maintain reliable sources for future generations.

Ground-Water Resources

Ground water provides approximately one-third of Illinois' population with drinking water. The sources of this water can be broken down into three major units: 1) sand and gravel, 2) shallow bedrock, and 3) deep bedrock. Most ground-water resources are centered in the northern two-thirds of Illinois.

Sand-and-gravel aquifers are found along many of the major rivers and streams across the state and also in "buried bedrock valley" systems created by complex glacial and interglacial episodes of surface erosion. There are also many instances of thin sand-and-gravel deposits in the unconsolidated materials above bedrock. These thin deposits are used throughout Illinois to meet the water needs of small towns. Shallow bedrock units are more commonly used in the northern third of Illinois, whereas deep bedrock units are most widely used in the northeastern quarter (in and around the Chicago area). The variety of uses and the volume of water used vary widely throughout the state. This report describes ground-water availability and use in the Illinois River Bluffs area.

Data Sources

Private Well Information

The Illinois State Water Survey (ISWS) has maintained well construction reports since the late 1890s. Selected information from these documents has been computerized and is maintained in the Private Well Database. These data are easily queried and summarized for specific needs and form the basis of well distribution studies in the area.

Public Well Information

Public Water Supply (PWS) well information has been maintained at the ISWS since the late 1890s. Municipal well books (or files) have been created for virtually all of the reported surface and ground-water PWS facilities in Illinois. Details from these files are assembled in the Public-Industrial-Commercial Database, which was created to house water well and water use information collected by the ISWS.

Ground-Water Use Information

The water use data given in this report come from the records compiled by the ISWS' Illinois Water Inventory Program (IWIP). This program was developed to document and facilitate planning and management of existing water resources in Illinois. Information for the program is collected through an annual water use summary mailed directly to each PWS facility.

Data Limitations

Several limitations must be taken into consideration when interpreting these data:

1. Information is reported by drillers and each PWS facility.
2. Data measuring devices are generally not very accurate.
3. Participation in the IWIP is voluntary.

Information assembled from well construction reports and from the IWIP is considered "reported" information. This means that the data are as accurate as the reliability of the individual reporting or as mechanical devices dictate. The quality of the reported information depends upon the skill or budget of the driller or facility, respectively. Moreover, the ISWS estimates that only one-third to one-half of the wells in the state are on file at the Survey, mainly due to the lack of reporting regulations prior to 1976.

In general, water use measuring devices, such as the meters used by PWS facilities, are not very accurate. In fact, errors of as much as 10% are not uncommon. Much of the information reported in the IWIP is estimated by the water operator or by program staff.

Participation in the program is not required by the State of Illinois, and each facility voluntarily reports its information through a yearly survey. However, not all facilities know of or respond to the water use questionnaire. After several mail and telephone attempts have been made to gather this information, estimates are made using various techniques. To help reduce errors associated with the program, reported water use information is checked against usage from previous years to identify any large-scale reporting errors.

Ground-Water Availability

The Illinois River Bluffs area encompasses portions of 9 counties: Bureau, LaSalle, Lee, Marshall, Peoria, Putnam, Stark, Tazewell, and Woodford. The portion of each county in the watershed varies from less than 1% (Stark County) to 96% (Marshall County). This section summarizes ground-water availability in the area, taking into consideration only those portions of each county that are actually in the watershed.

Domestic and Farm Wells

Available regional information indicates that ground water for domestic and farm use in the area is mostly obtained from two types of wells finished in the till (Salkregg, Kempton, 1958). Table 16 summarizes the number of reported private wells in the watershed by county and depth.

Table 16. Number of Reported Private Wells in the Illinois River Bluffs Area
(Source: ISWS Private Well Database)

	Depth range, feet								
County	0-50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	400+
Bureau		4	4	5	12	5			4
LaSalle	10	14	12	1					3
Lee		1							
Marshall	209	211	109	33	99	27	10	3	9
Peoria	246	483	172	98	56	15	17	14	13
Putnam	90	90	66	40	44	15	1	1	5
Stark			3	4	1				
Tazewell	92	61	12	8	26	18	61	6	2
Woodford	148	273	187	78	112	98	76	32	3
Total	795	1,137	565	267	350	178	165	56	39

Public Water Supply Wells

Information from the ISWS' Public-Industrial-Commercial Database indicates that most ground water for PWS use in the area comes from wells finished in the unconsolidated materials, generally the Sankoty sand, which supplies about 96% of the groundwater withdrawn. The Cambrian-Ordovician systems supply the remaining 4%.

Unconsolidated wells range in depth from 23 to 408 feet, while bedrock wells range in depth from 320 to 2,000 feet. A total of 40 public water supplies withdraw 13.50 million gallons per day (mgd), servicing a reported 199,872 residents at an average per capita daily water use of 71.7 gallons per day (gpd).

1995 Ground-Water Use

Ground water constitutes a substantial portion of the total water used in the basin. Total ground-water use in the basin during 1995 is estimated to be 17.04 mgd, with 13.50 mgd for PWS facilities, 2.14 mgd for self-supplied industries (SSI), 0.84 mgd for rural/domestic uses, and 0.56 mgd for livestock watering.

<u>Public Water Supply</u>
In 1995, municipal residential use for 40 communities using ground water was reported to be 11.70 mgd, serving a combined population of 199,872. The average per capita use from these municipalities is 71.7 gpd. The facilities also delivered 1.80 mgd for industrial and commercial use.

<u>Self-Supplied Industry</u>
Self-supplied industries are defined as those facilities that meet all or a portion of their water needs from their own sources. In the Illinois River Bluffs area, 12 SSI facilities reported total ground-water pumpage of 2.14 mgd during 1995.

<u>Rural/Domestic</u>
There is no direct method for determining rural/domestic water use in the basin. To get a rough estimate for the area, several assumptions were made using existing information. The population served and number of services reported by PWS facilities were used to calculate an average population per service for all PWS facilities in the area. This number was used as an estimate of population per reported domestic well. The average PWS per capita use was then used as a multiplier to determine the total rural/domestic water use from each well. Based on information from the ISWS Private Well Database, which shows 3,646 reported wells in the Illinois River Bluffs area, an average of 3.2 people per service (well), and an average of 71.7 gpd per person, total rural/domestic water use was estimated to be 0.84 mgd.

<u>Livestock Watering</u>
Water withdrawals for livestock use in 1995 were estimated to be 0.56 mgd. Water use estimates for livestock are based on a fixed amount of water use per head for each type of animal. Percentages of the total animal population (Illinois Department of Agriculture, 1995) for the major livestock (cattle and hogs) in the counties were calculated based upon the percentage of county acres in the Illinois River Bluffs area. Daily consumption rates (beef cattle = 12 gpd, all other cattle = 35 gpd, and hogs = 4 gpd) provided the basis for these calculations.

Ground-Water Use Trends

Ground-water use in the Illinois River Bluffs area has remained relatively constant over the last six years. During this period, total ground-water use has averaged 13.84 mgd and ranged from 12.58 to 15.64 mgd; PWS use has averaged 11.85 mgd and ranged from 10.15 to 13.78 mgd; and SSI use has averaged 1.99 mgd and ranged from 1.33 to 2.55 mgd. Table 17 shows the individual totals per year since 1990. No significant trends are evident in terms of water withdrawals in the basin.

Table 17. Ground-Water Use Trends in the Illinois River Bluffs Area
(in million gallons per day, mgd)

Year	PWS	SSI	Total
1990	10.15	2.55	12.70
1991	10.95	2.03	12.97
1992	10.68	1.90	12.58
1993	13.78	1.33	15.10
1994	12.07	1.98	14.05
1995	13.50	2.14	15.64
Average	11.85	1.99	13.84

Surface Water Resources

The rivers, streams, and lakes of the Illinois River Bluffs area serve a wide variety of purposes, including uses for public water supply, recreation (boating, fishing, and swimming), and habitat for aquatic life. The primary focus of this section is on water withdrawn from streams for public water supply and the surface water resources available for such use.

Water supply systems generally obtain surface water in one of three manners: 1) direct withdrawal from a stream, 2) impoundment of a stream to create a storage reservoir, and 3) creation of an off-channel (side-channel) storage reservoir into which stream water is pumped. As described below, there is substantial potential for direct withdrawals from the Illinois River for water supply, and several locations along the river bluffs for potential impounding reservoirs. The potential for side-channel storage also exists along most streams.

Water Use and Availability

The only major user of surface water for water supply in the Illinois River Bluffs area is the city of Peoria, which withdraws water from the Illinois River. Over the six year period, 1990-1995, the average amount of water withdrawal from the river has been 8.35 million gallons per day (mgd), or roughly 46 percent of that used for the city's public water supply. The only other use of surface water in the area is a small industrial supply which reports pumping 0.03 mgd.

Most of the small communities and industries in the Illinois River Bluffs area discharge their treated wastewater into the Illinois River. However, the total amount of these effluents is fairly small, totaling less than 4 mgd. The city of Peoria discharges their treated wastewater downstream of Peoria Lake. There are a few small discharges into tributary streams, but these are not sufficient to significantly alter the flow characteristics of such streams.

Potential for Development of Surface Water Supplies

Direct Withdrawals from Streams

The Illinois River is the only reach of stream in the area that is able to support a direct withdrawal for water use. There are no practical limitations on the amount of water use that could be supported by the river, and no anticipated negative impacts to its potential use.

Impounding Reservoirs

The tributaries in the Illinois River Bluffs area provide a number of possible reservoir sites, primarily because of their valley slopes. Figure 34 shows the locations of 19 potential reservoir sites in the region, as given in Dawes and Terstriep (1966, 1967). Many of the potential reservoir sites could support a safe yield in excess of 2 mgd.

In general, the construction of impounding reservoirs has become a less common option for developing a water supply, primarily because of costs and environmental concerns. As a result, the proximity of alternative sources should be considered in their proposed development. Since the Illinois River provides an ample supply of water, the reservoir sites that are farther from the river are the ones of greatest interest.

Side-Channel Reservoirs

There are no side-channel reservoirs in the Illinois River Bluffs area. The construction of side-channel reservoirs is generally not limited by local topography and could be a viable water supply option for a small water supply along most of the tributary streams in the basin. The amount of water supply that off-channel storage can provide is limited primarily by the temporal distribution of flow in the stream and the size of the storage reservoir.

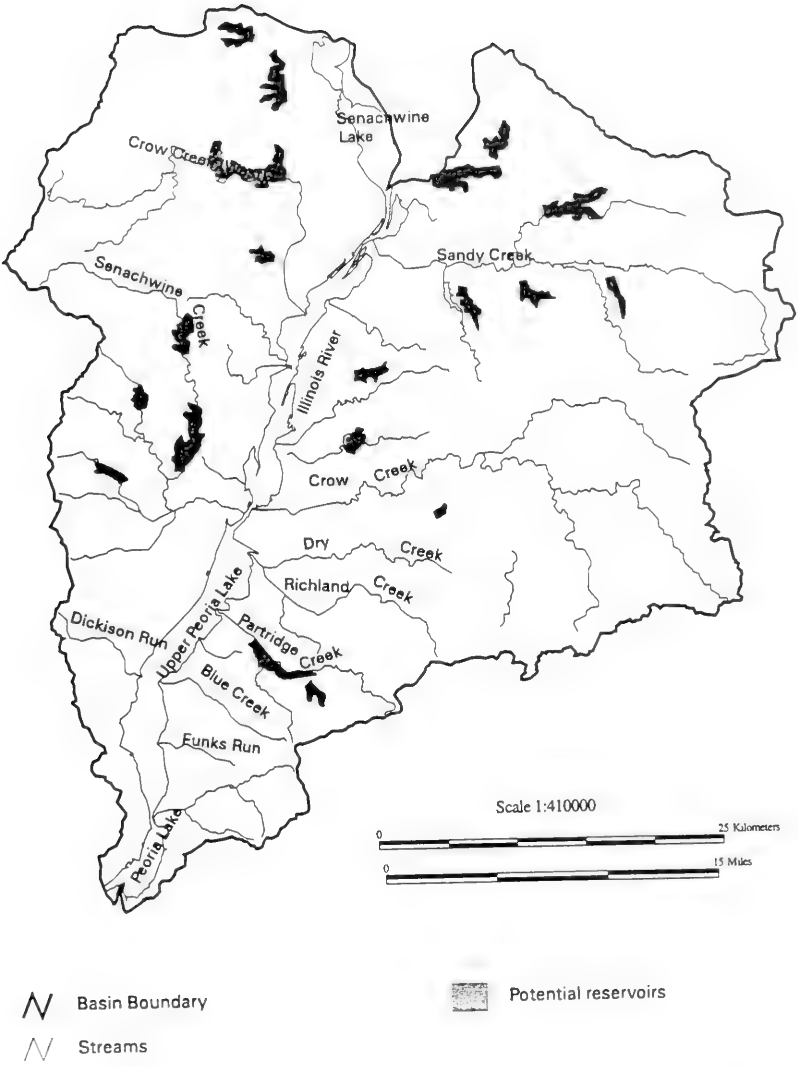


Figure 34. Potential Reservoirs in the Illinois River Bluffs

Ground-Water Quality

This section examines ground-water quality records to determine temporal trends and to provide baseline water quality parameters in the Illinois River Bluffs area. Increasingly, ground-water contamination is discussed in the news media, and it may seem that the entire ground-water resource has been affected. However, these contamination events are often localized and may not represent widespread degradation of the ground-water resource. By examining the temporal trends in ground-water quality in the area, it may be possible to determine whether large-scale degradation of the ground-water resource has occurred.

The general term "ground-water quality" refers to the chemical composition of ground water. Ground water originates as precipitation that filters into the ground. As the water infiltrates the soil, it begins to change chemically due to reactions with air in the soil and with the earth materials through which it flows. Human-induced chemical changes can also occur. In fact, contamination of ground water is generally the result of human-induced chemical changes and not naturally occurring processes.

As a general rule, local ground-water quality tends to remain nearly constant under natural conditions because of long ground-water travel times. Therefore, significant changes in ground-water quality can indicate degradation of the ground-water resource.

Data Sources

The ground-water quality data that are used in this report come from two sources: private wells and municipal wells. The private well water quality data are compiled by the Chemistry Division of the Illinois State Water Survey (ISWS) as part of its water testing program and are maintained by the Office of Ground-Water Information in a water quality database. The municipal well data come from ISWS analyses and from the Illinois Environmental Protection Agency (IEPA) laboratories.

The combined database now contains more than 50,000 records of chemical analyses from samples analyzed at the ISWS and IEPA laboratories. Some of these analyses date to the early part of the century, but most are from 1970 to the present. Before 1987, most analyses addressed inorganic compounds and physical parameters. Since then, many organic analyses have been added to the database from the IEPA Safe Drinking Water Act compliance monitoring program. This report presents information for only a portion of the chemical parameters in the ISWS database.

Data Limitations

Several limitations must be understood before meaningful interpretation of the water quality data can begin:

1. Representativeness of the sample
2. Location information
3. Data quality (checked by charge balance)
4. Extrapolation to larger areas

Generally, private well samples are not representative of regional ground-water quality. In most cases, private well owners submit samples for analysis only when they believe there may be a problem such as high iron or an odd odor or taste. However, while one or more constituents may not be representative, in general the remainder of the chemical information will be accurate and useful. As a result, the composite data may be skewed toward analyses with higher than normal concentrations.

On the other hand, private well information probably gives a better picture of the spatial distribution of chemical ground-water quality than municipal well information because of the larger number of samples spread over a large area. Recent IEPA data from municipal wells will not be skewed because each well is sampled and analyzed on a regular basis. While this produces a much more representative sample overall, samples are generally limited to specific areas where municipalities are located. Therefore, these data may not be good indicators of regional ground-water quality.

Much of the location information for the private wells is based solely on the location provided by the driller at the time the well was constructed. Generally, locations are given to the nearest 10-acre plot of land. For this discussion, that degree of resolution is adequate. However, it is not uncommon for a given location to be in error by as much as 6 miles. To circumvent possible location errors, this report presents results on a watershed basis.

The validity of water quality data was not checked for this report. However, previous charge balance checking of these data was conducted for a similar statewide project (Illinois Department of Energy and Natural Resources, 1994). Charge balance is a simple measure of the accuracy of a water quality analysis. It measures the deviation from the constraint of electrical neutrality of the water by comparing total cations (positively charged ions) with total anions (negatively charged ions). Because many of the early analyses were performed for specific chemical constituents, a complete chemical analysis is not always available from which to calculate a charge balance.

The statewide study searched the water quality database for analyses with sufficient chemical constituents to perform an ion balance. The charge balance checking of those data found that more than 98% of the analyses produced acceptable mass balance, which suggests that the chemical analyses are accurate in the database. Using that assumption

for this report, we feel confident that most of the analyses used are accurate and give representative water quality parameters for the Illinois River Bluffs area. However, this may be true only for large samples, a factor that should be considered when reviewing the results, as this report presents data from ten decades and a wide range of sample sizes.

Extrapolating a point value (a well water sample) to a regional description of ground-water quality is difficult theoretically and beyond the scope of this report. However, none of the data provide a uniform spatial coverage. Therefore, it seems best to summarize the data on a watershed basis to ensure an adequate number of values. The private well analyses are more numerous and will likely provide better spatial coverage than the municipal well data, which are concentrated in isolated locations.

Chemical Components Selected for Trend Analysis

In many cases, ground-water contamination involves the introduction into ground water of industrial or agricultural chemicals such as organic solvents, heavy metals, fertilizers, and pesticides. However, recent evidence suggests that many of these contamination occurrences are localized and form finite plumes that extend down gradient from the source. Much of this information is relatively recent, dating back a few decades, and long-term records at any one site are rare.

As mentioned earlier, changes in the concentrations of naturally occurring chemical elements such as chloride, sulfate, or nitrate also can indicate contamination. For instance, increasing chloride concentrations may indicate contamination from road salt or oil field brine, while increasing sulfate concentrations may be from acid wastes such as metal pickling, and increasing nitrate concentrations may result from fertilizer application, feed-lot runoff, or leaking septic tanks. These naturally occurring substances are the major components of mineral quality in ground water and are routinely included in ground-water quality analyses.

Fortunately, the ISWS has maintained records of routine water quality analyses of private and commercial wells that extend as far back as the 1890s. After examination of these records, six chemical constituents were chosen for trend analyses based on the large number of available analyses and because they may be indicators of human-induced degradation of ground-water quality. These components are iron (Fe), total dissolved solids (TDS), sulfate (SO_4), nitrate (NO_3), chloride (Cl), and hardness (as $CaCO_3$).

Aquifer Unit Analysis

Ground water occurs in many types of geological materials and at various depths below the land surface. This variability results in significant differences of natural ground-water quality from one part of Illinois to another and from one aquifer to the next even at the same location. For the purpose of this trend analysis, wells that were finished in

unconsolidated sand and gravel units were grouped together, as were wells finished in bedrock units. Unconsolidated units are by far the most frequently used in the Illinois River Bluffs area. Out of the more than 3,646 private wells reported in the watershed, 3,095 indicate penetration into unconsolidated units. From the water quality analyses in the ISWS water quality database, 833 of 940 wells indicated that the water for the sample came from the unconsolidated units. In this report, unconsolidated and bedrock aquifers are treated separately in the descriptions of each chemical constituent.

Discussion and Results

Temporal trends in the six chemical constituents from unconsolidated and bedrock materials are summarized in this section. Tables 18 and 19 present the results of each decade's analyses, including the maximum, minimum, mean, and median for each of the six chemical constituents for unconsolidated and bedrock materials, respectively.

Median values are given in the tables by decade, beginning with 1900-1909 (Decade 0), 1910-1919 (Decade 1), and so on through the 1990s (Decade 9). Each decade covers the corresponding ten-year period, except for the partial decade of the 1990s. Median concentrations are given per decade so that temporal trends can be identified in the data set. Median values are the midpoints of a set of data, above which lie half the data points and below which is found the remaining half. These values are used to look at the central tendency of the data set. Although the arithmetic mean would also look at this statistic, it incorporates all data points into its analysis, which can move the mean value in one direction or another based upon maximum or minimum values.

Outliers occur in many data sets. These are extreme values that tend to stand alone from the central values of the data set. They may lead to a false interpretation of the data set, whereas the median values are true values that are central to the data set. By looking at the median we can determine trends in the central portions of the data. However, for data sets with a small number of samples, the median may not necessarily be representative of the water quality in the area.

It is important to recognize that the values included in these tables are reported values. While every attempt to verify the values was made, the *validity* of each value with regard to method error, etc. is not known. For this reason, the tables include every analysis in the database and all analysis results regardless of whether a value seems excessive and regardless of the sample size in the decade.

Table 18. Chemical Constituents Selected for Trend Analysis, Unconsolidated Systems

Chemical constituent	Decade 0	1	2	3	4	5	6	7	8	9
Iron (Fe)										
Sample size (N)	36	3	1	67	169	19	55	210	183	53
Minimum (mg/L)	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Maximum (mg/L)	3.2	3.0	0.1	28.0	16.2	4.7	8.7	14.0	16.3	4.1
Mean (mg/L)	0.7	1.0	0.1	0.8	1.7	0.9	1.5	1.4	1.5	0.6
Median (mg/L)	0.2	0.1	0.1	0.2	0.7	0.2	0.7	0.3	0.6	0.1
TDS										
Sample size (N)	39	6	1	68	188	19	49	207	181	52
Minimum (mg/l)	350.0	417.0	557.0	313.0	306.0	366.0	308.0	248.0	270.0	125.0
Maximum (mg/l)	1476.0	794.0	557.0	1964.0	1722.0	1088.0	2891.0	1179.0	1510.0	1226.0
Mean (mg/l)	506.5	554.2	557.0	648.5	517.0	562.1	590.8	475.5	463.2	434.2
Median (mg/l)	455.0	529.5	557.0	514.5	452.5	464.0	454.0	449.0	431.0	431.0
Sulfate (SO_4)										
Sample size (N)	26	4	1	67	179	5	8	145	177	52
Minimum (mg/l)	0.0	45.0	113.0	0.0	0.0	57.0	0.0	0.0	5.0	10.0
Maximum (mg/l)	385.0	110.0	113.0	592.0	559.0	447.0	235.0	370.0	868.0	233.0
Mean (mg/l)	85.5	75.2	113.0	126.2	70.7	206.8	101.0	51.3	56.9	57.7
Median (mg/l)	60.5	73.0	113.0	80.0	44.0	93.0	59.5	45.0	37.0	51.0
Nitrate (NO_3)										
Sample size (N)	29	4	1	66	66	17	34	173	10	0
Minimum (mg/l)	0.0	1.0	31.9	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Maximum (mg/l)	73.0	61.9	31.9	64.0	96.0	266.2	107.0	96.6	28.8	0.0
Mean (mg/l)	13.2	18.3	31.9	13.0	6.9	34.9	21.1	10.1	12.7	0.0
Median (mg/l)	0.0	5.1	31.9	11.1	4.2	5.9	5.2	2.2	11.1	0.0
Chloride (Cl)										
Sample size (N)	40	7	1	68	187	19	51	206	183	52
Minimum (mg/l)	3.0	2.0	29.0	2.0	1.0	4.0	1.0	0.0	0.0	1.1
Maximum (mg/l)	213.0	72.0	29.0	707.0	575.0	142.0	375.0	280.0	209.0	56.0
Mean (mg/l)	25.0	40.4	29.0	66.0	27.4	25.7	32.7	16.2	16.7	22.3
Median (mg/l)	18.0	50.0	29.0	15.5	15.0	9.0	12.0	12.0	13.0	16.0
Hardness (as $CaCO_3$)										
Sample size (N)	36	1	1	68	191	19	51	191	112	18
Minimum (mg/l)	232.0	153.0	407.0	36.0	4.0	336.0	202.0	148.0	152.0	287.0
Maximum (mg/l)	590.0	153.0	407.0	735.0	1224.0	1044.0	1810.0	650.0	652.0	521.0
Mean (mg/l)	379.2	153.0	407.0	423.7	379.4	462.1	414.8	358.4	341.4	374.8
Median (mg/l)	374.0	153.0	407.0	398.5	352.0	404.0	342.0	348.0	334.0	369.6

*Note: Decade 0=1900-1909, Decade 1=1910-1919, and so on.

Table 19. Chemical Constituents Selected for Trend Analysis, Bedrock Aquifer Systems

Chemical constituent	Decade 0	1	2	3	4	5	6	7	8	9
Iron (Fe)										
Sample size (N)	3	0	1	14	8	21	12	38	20	3
Minimum (mg/L)	0.3	0.0	0.4	0.0	0.0	0.2	0.1	0.0	0.0	0.4
Maximum (mg/L)	4.0	0.0	0.4	6.0	21.9	22.0	14.0	17.0	1.6	0.9
Mean (mg/L)	1.6	0.0	0.4	1.6	5.2	4.4	1.9	1.5	0.6	0.7
Median (mg/L)	0.4	0.0	0.4	0.3	2.4	1.2	0.8	0.6	0.5	0.7
TDS										
Sample size (N)	4	1	1	14	8	24	12	37	20	3
Minimum (mg/l)	1260.0	1461.0	1454.0	356.0	374.0	1323.0	465.0	330.0	359.0	1110.0
Maximum (mg/l)	3154.0	1461.0	1454.0	3301.0	4186.0	3688.0	1510.0	6764.0	3428.0	2190.0
Mean (mg/l)	1916.0	1461.0	1454.0	1671.6	1571.2	1757.5	1049.9	1316.8	1581.0	1650.0
Median (mg/l)	1625.0	1461.0	1454.0	1446.5	1545.0	1554.5	1318.5	1306.0	1452.5	1650.0
Sulfate (SO_4)										
Sample size (N)	4	1	1	14	7	10	5	31	19	3
Minimum (mg/l)	107.0	181.0	176.0	0.0	27.0	110.0	0.0	51.0	59.0	208.0
Maximum (mg/l)	225.0	181.0	176.0	555.0	515.0	280.0	232.0	390.0	422.0	396.0
Mean (mg/l)	176.8	181.0	176.0	190.3	215.6	224.8	184.4	216.6	212.8	284.7
Median (mg/l)	187.5	181.0	176.0	174.0	183.0	233.0	230.0	220.0	218.0	250.0
Nitrate (NO_3)										
Sample size (N)	4	1	1	14	1	2	4	28	3	0
Minimum (mg/l)	0.0	0.7	1.0	0.8	0.8	0.6	0.3	0.0	0.3	0.0
Maximum (mg/l)	0.9	0.7	1.0	14.2	0.8	0.7	51.6	21.8	2.5	0.0
Mean (mg/l)	0.2	0.7	1.0	3.8	0.8	0.6	15.1	2.3	1.1	0.0
Median (mg/l)	0.0	0.7	1.0	1.7	0.8	0.6	4.2	0.4	0.5	0.0
Chloride (Cl)										
Sample size (N)	5	2	1	14	8	25	12	37	20	3
Minimum (mg/l)	360.0	580.0	458.0	2.0	9.0	420.0	1.0	3.0	12.0	200.0
Maximum (mg/l)	1725.0	725.0	458.0	1683.0	2050.0	1900.0	560.0	3750.0	1720.0	956.0
Mean (mg/l)	722.0	652.5	458.0	633.7	545.9	645.4	267.6	449.3	610.1	588.0
Median (mg/l)	485.0	652.5	458.0	505.5	382.5	540.0	300.0	450.0	534.5	608.0
Hardness (as $CaCO_3$)										
Sample size (N)	3	0	0	14	8	25	12	32	14	3
Minimum (mg/l)	244.0	0.0	0.0	26.0	200.0	42.0	52.0	24.0	23.0	80.0
Maximum (mg/l)	430.0	0.0	0.0	1088.0	397.0	348.0	1090.0	508.0	416.0	325.0
Mean (mg/l)	321.3	0.0	0.0	278.1	285.8	223.1	265.2	269.6	215.6	187.7
Median (mg/l)	290.0	0.0	0.0	233.0	251.5	220.0	214.0	255.0	210.5	158.0

*Note: Decade 0=1900-1909, Decade 1=1910-1919, and so on.

Iron (Fe)

Iron in ground water occurs naturally in the soluble (ferrous) state. However, when exposed to air, iron becomes oxidized into the ferric state and forms fine to fluffy reddish-brown particles that will settle to the bottom of a container if allowed to sit long enough. The presence of iron in quantities much greater than 0.1 to 0.3 milligrams per liter (mg/l) usually causes reddish-brown stains on porcelain fixtures and laundry. The drinking water standards recommend a maximum limit of 0.3 mg/l iron to avoid staining (Gibb, 1973).

Unconsolidated Systems

Iron concentrations for unconsolidated systems in the watershed are given for each decade in Table 18. Minimum and maximum concentrations for all ten decades are 0.0 and 28.0 mg/l, respectively. These values clearly indicate a great deal of spatial variability in iron in the watershed. The median values range from 0.1 to 0.7 mg/l for all ten decades. While these median values show relatively high concentrations that could cause staining of porcelain fixtures (greater than 0.3 mg/l), they generally pose no threat to human health. In addition, the median values are all well above the Class I potable ground-water supply standard of 0.5 mg/l. Table 18 suggests no significant trend in iron concentrations in the area.

Bedrock Aquifer Systems

Iron concentrations for bedrock aquifer systems in the watershed are given for each decade in Table 19. Minimum and maximum concentrations for all ten decades are 0.0 and 22.0 mg/l, respectively. These values clearly indicate a great deal of spatial variability in iron in the watershed. The median values range from 0.3 to 2.4 mg/l for all ten decades. While these median values show relatively high concentrations that could cause staining of porcelain fixtures (greater than 0.3 mg/l), they generally pose no threat to human health. Table 19 suggests no significant trend in iron concentrations in the area.

Total Dissolved Solids (TDS)

The TDS content of ground water is a measure of the mineral solutes in the water. Water with a high mineral content may taste salty or brackish depending on the types of minerals in solution and their concentrations. In general, water containing more than 500 mg/l TDS will taste slightly mineralized. However, the general public can become accustomed to the taste of water with concentrations of up to 2,000 mg/l. Water containing more than 3,000 mg/l TDS generally is not acceptable for domestic use, and at 5,000 to 6,000 mg/l, livestock should not drink the water. Because TDS concentration is a lumped measure of the total amount of dissolved chemical constituents in the water, it will not be a sensitive indicator of trace-level contamination. However, it is a good indicator of major inputs of ions or cations to ground water.

Unconsolidated Systems

TDS concentrations in the unconsolidated systems in the watershed are given for each decade in Table 18. Minimum and maximum concentrations for all ten decades are 125.0 and 2,891.0 mg/l, respectively. Median values range from 431.0 to 557.0 mg/l for all ten decades. Generally, there are no significant trends in TDS concentrations in these aquifer systems in the watershed.

Bedrock Aquifer Systems

TDS concentrations for bedrock aquifer systems in the watershed are reported for each decade in Table 19. Minimum and maximum concentrations for all ten decades are 330.0 and 6,764.0 mg/l, respectively. Median values range from 1,306.0 to 1,650.0 mg/l for all ten decades. Generally, there are no significant trends in TDS concentrations in bedrock aquifer systems in the watershed. Any fluctuations from one decade to the next are more likely related to data limitations than to any inherent changes in ground-water quality.

Sulfate (SO_4)

Water with high sulfate concentrations often has a medicinal taste and a pronounced laxative effect on those not accustomed to it. Sulfates generally are present in aquifer systems in one of three forms: magnesium sulfate (sometimes called Epsom salt), sodium sulfate (Glauber's salt), or calcium sulfate (gypsum). They also occur in earth materials in a soluble form that is the source for natural concentrations of this compound. Human sources similar to those for chloride also can contribute locally to sulfate concentrations. Coal mining operations particularly are a common source of sulfate pollution, as are industrial wastes. Drinking water standards recommend an upper limit of 250 mg/l for sulfates. Upward trends in sulfate concentrations can suggest potential ground-water pollution.

Unconsolidated Systems

Sulfate concentrations for unconsolidated systems in the watershed are reported for each decade in Table 18. Minimum and maximum concentrations for all ten decades are 0.0 and 868.0 mg/l, respectively. Median values are all well below the drinking water standard, and range from 37.0 to 113.0 mg/l for all ten decades. Fluctuations from one decade to the next are more likely related to data limitations than to any inherent changes in ground-water quality.

Bedrock Aquifer Systems

Sulfate concentrations for bedrock aquifer systems in the watershed are reported for each decade in Table 19. Minimum and maximum concentrations for all ten decades are 0.0 and 555.0 mg/l, respectively. Median values are all well below the drinking water standard, and range from 174.0 to 250.0 mg/l for all ten decades. Table 19 indicates variability, but no significant trends in sulfate concentrations in the watershed. Fluctuations from one decade to the next are more likely related to data limitations than to any inherent changes in ground-water quality.

Nitrate (NO_3)

Nitrates are considered harmful to fetuses and children under the age of one when concentrations in drinking water supplies exceed 45 mg/l (as NO_3), or the approximate equivalent of 10 mg/l nitrogen (N). Excessive nitrate concentrations in water may cause "blue baby" syndrome (methmoglobinemia) when such water is used in the preparation of infant feeding formulas. Inorganic nitrogen fertilizer has proven to be a source of nitrate pollution in some shallow aquifers, and may become an even more significant source in the future as ever increasing quantities are applied to Illinois farmlands. Upward trends in concentrations of nitrate may be a good indication that farm practices in the area are affecting the ground-water environment.

Unconsolidated Systems

Nitrate concentrations for unconsolidated systems in the watershed are reported for each decade in Table 18. Minimum and maximum concentrations for all ten decades are 0.0 and 266.2 mg/l, respectively. Maximum concentrations should be viewed as an outlier of the dataset, and not as representative of the water quality in the area. The majority of the median values are well below the drinking water standards, and range from 0.0 to 31.9 mg/l for all ten decades. However, the ISWS has documented numerous cases of elevated nitrate levels associated with rural private wells in and around this area (Wilson et al., 1992). The evidence suggests that rural well contamination is associated more with farmstead contamination of the local ground water or well than with regional contamination of major portions of an aquifer from land application of fertilizers. This topic is actively being studied.

Bedrock Aquifer Systems

Nitrate concentrations for bedrock aquifer systems in the watershed are reported for each decade in Table 19. Minimum and maximum concentrations for all ten decades are 0.0 and 51.6 mg/l, respectively. Median values are well below the drinking water standards, and range from 0.0 to 4.2 mg/l for all ten decades.

Chloride (Cl)

Chloride is generally present in aquifer systems as sodium chloride or calcium chloride. Concentrations greater than about 250 mg/l usually cause the water to taste salty. Chloride occurs in earth materials in a soluble form that is the source for normal concentrations of this mineral in water. Of the constituents examined in this report, chloride is one of the most likely to indicate the impacts of anthropogenic activity on ground water. Upward trends in chloride concentrations may indicate contamination from road salt or oil field brine. The drinking water standards recommend an upper limit of 250 mg/l for chloride. In sand and gravel aquifers throughout most of the state, chloride concentrations are usually less than 10 mg/l.

Unconsolidated Systems

Chloride concentrations for unconsolidated systems in the watershed are reported for each decade in Table 18. Minimum and maximum concentrations for all ten decades are 0.0 and 707.0 mg/l, respectively. Median values are well below the drinking water standard, and range from 9.0 to 50.0 mg/l for all ten decades. Table 18 indicates no significant trends in chloride concentrations in the watershed.

Bedrock Aquifer Systems

Chloride concentrations for bedrock aquifer systems in the watershed are reported for each decade in Table 19. Minimum and maximum concentrations for all ten decades are 1.0 and 3,750.0 mg/l, respectively. Median values range from 300.0 to 652.5 mg/l for all ten decades. Table 19 indicates no significant trends in median chloride concentrations in the watershed. Fluctuations from one decade to the next are more likely related to data limitations than to any inherent changes in ground-water quality.

Hardness (as $CaCO_3$)

Hardness in water is caused by calcium and magnesium. These hardness-forming minerals generally are of major importance to users since they affect the consumption of soap and soap products and produce scale in water heaters, pipes, and other parts of the water system. The drinking water standards do not recommend an upper limit for hardness. The distinction between hard and soft water is relative, depending on the type of water a person is accustomed to. The ISWS categorizes water from 0 to 75 mg/l as soft, 75 to 125 mg/l as fairly soft, 125 to 250 mg/l as moderately hard, 250 to 400 mg/l as hard, and over 400 mg/l as very hard.

Unconsolidated Systems

Hardness concentrations for unconsolidated systems in the watershed are reported for each decade in Table 18. Minimum and maximum concentrations for all ten decades are 4.0 and 1.810.0 mg/l, respectively. Median values range from 153.0 to 407.0 mg/l for all ten decades, indicating moderately hard to hard water in this area.

Bedrock Aquifer Systems

Hardness concentrations for bedrock aquifer systems in the watershed are reported for each decade in Table 19. Minimum and maximum concentrations for all ten decades are 23.0 and 1,090.0 mg/l, respectively. Median values range from 158.0 to 290.0 mg/l for all ten decades. The water is considered moderately hard in this area. No trends are observed in hardness concentrations from the bedrock in this area.

Summary

This work was undertaken to examine long-term temporal trends in ground-water quality in the Illinois River Bluffs area. Data from private and municipal wells were the primary sources of information used to show the trends in six chemical constituents of ground water in the area. These data demonstrate that on a watershed scale, ground water has not been degraded with respect to the six chemicals examined. Fluctuations from one decade to the next are more likely related to data limitations than to any inherent changes in ground-water quality. It is also evident that the sample size in each decade can play a role in trend analysis.

Much of the contamination of Illinois' ground water is localized. Nonetheless, this contamination can render a private or municipal ground-water supply unusable. Once contaminated, ground water is very difficult and expensive to clean, and clean-up may take many years to complete. Clearly it is in the best interests of the people of Illinois to protect their ground-water resource through prevention of contamination.

Although no significant trends in water quality for these six constituents are apparent, the information provides baseline water quality for the watershed. This information can be used in future studies of the area as a reference to determine whether the local ground-water quality is degrading.

References

Introduction

Illinois Department of Natural Resources. 1996. Illinois Land Cover, An Atlas. IDNR-96/05. Springfield, IL.

Illinois Department of Natural Resources. 1996. Illinois Land Cover, An Atlas. Compact Disc. Springfield, IL.

Leighton, M.M., G.E. Ekblaw, and L. Horberg. 1948. Physiographic Divisions of Illinois. Illinois State Geological Survey Report of Investigation 129. Champaign, IL.

Mattingly, R.L., and E.E. Herricks. 1991. Channelization of Streams and Rivers in Illinois: Procedural Review and Selected Case Studies. Illinois Department of Natural Resources Report ILENR/RE-WR-91/01.

Suloway, L., and M. Hubbell. 1994. Wetland Resources of Illinois: An Analysis and Atlas. Illinois Natural History Survey Special Publication 15. Champaign, IL.

Climate and Trends in Climate

Changnon, S.A., Jr. 1984. Climate Fluctuations in Illinois: 1901-1980. Illinois State Water Survey Bulletin 68. Champaign, IL.

Changnon, S.A., Jr. 1995. Temporal Fluctuations of Hail in Illinois. Illinois State Water Survey Miscellaneous Publication 167. Champaign, IL.

Illinois Department of Energy and Natural Resources. 1994. The Changing Illinois Environment: Critical Trends. Volume 1: Air Resources. ILENR/RE-EA-94/05(1). Springfield, IL.

Streamflow

Knapp, H.V. 1994. Hydrologic Trends in the Upper Mississippi River Basin. *Water International* 19 (4): 199-206.

Kunkel, K.E., K. Andsager, and D.R. Easterling. 1997. Trends in Heavy Precipitation Events over the Continental U.S. Manuscript.

Ramamurthy, G.S., K.P. Singh, and M.L. Terstriep. 1989. Increased Duration of High Flows along the Illinois and Mississippi Rivers: Trends and Agricultural Impacts. Illinois State Water Survey Contract Report 478.

Erosion and Sedimentation

Demissie, M., L. Keefer, R. Xia. 1992. Erosion and Sedimentation in the Illinois River Basin. ILENR/RE-WR-92/04, Springfield, IL.

Water Use and Availability

Dawes, J.H., and M.L. Terstriep. 1966. Potential Surface Water Resources of North-Central Illinois. Illinois State Water Survey Report of Investigation 56.

Dawes, J.H., and M.L. Terstriep. 1967. Potential Surface Water Resources of North-Central Illinois. Illinois State Water Survey Report of Investigation 58.

Illinois Department of Energy and Natural Resources. 1994. The Changing Illinois Environment: Critical Trends. Volume 2: Water Resources. ILENR/RE-EA-94/05(2). Springfield, IL.

Selkregg, L.F., and Kempton, J.P., 1958. Groundwater Geology in East-Central Illinois, Illinois State Geological Survey Circular 248.

Ground-Water Quality

Gibb, J.P. 1973. Water Quality and Treatment of Domestic Groundwater Supplies. Illinois State Water Survey Circular 118. Champaign, IL.

Illinois Department of Energy and Natural Resources. 1994. The Changing Illinois Environment: Critical Trends. Volume 2: Water Resources ILENR/RE-EA-94/05(2). Springfield, IL.

Wilson, S.D., K.J. Hlinka, J.M. Shafer, J.R. Karny, and K.A. Panczak. 1992. "Agricultural chemical contamination of shallow-bored and dug wells." In Research on Agricultural Chemicals in Illinois Groundwater: Status and Future Directions II. Proceedings of the second annual conference, Illinois Groundwater Consortium, Southern Illinois University, Carbondale, IL.